

Education Applications & Developments X



Editor: Mafalda Carmo

Advances in Education and Educational Trends

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Advances in Education and Educational Trends Series

Edited by: Mafalda Carmo



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FOREWORD

inScience Press is delighted to publish this book entitled *Education Applications & Developments X* as part of the Advances in Education and Educational Trends books series. These series comprise the work of authors and editors to address global research in the Education area.

In this tenth volume, a dedicated group of authors delves into the field of Education, contributing to the advancement of knowledge and innovation. True progress in this area relies on the active participation of individuals committed to finding creative solutions and believing in their potential to effect meaningful change. Our goal is to inspire greater public engagement and foster collaboration within and across communities. As part of our ongoing mission to serve society, we emphasize the importance of strengthening research efforts, promoting education and science, and encouraging interdisciplinary cooperation. We believe that connecting diverse perspectives and areas of expertise is essential to driving forward impactful and inclusive educational practices.

This 10th edition addresses some of the most significant and current issues in contemporary educational research. This book explores four major areas within the broad spectrum of Education, corresponding to four sections: “*Teachers and Students*”, “*Projects and Trends*”, “*Teachers and Learning*”, and “*Organizational Issues*”. Each section comprises chapters that have emerged from extended and peer reviewed selected papers, originally published last year in the proceedings of the International Conference on Education and New Developments (END 2024) conference series (<http://end-educationconference.org/>). This meeting occurs annually with consistently successful outcomes. Selected original papers were expanded by their authors and underwent a renewed evaluation process. Following this, authors of the accepted chapters were invited to revise and improve their work based on the reviewers’ feedback. This rigorous process culminated in the publication of 42 high-quality chapters, structured across four major areas. The following sections and chapters’ abstracts provide further insights into the content of this volume.

Section 1, entitled “Teachers and Students”, provides studies within educational programs and pedagogy for both teachers and students.

Chapter 1: *On scoring competence*; by Magne V. Aarset & Stig Ytterstad. The overall objective of any learning process is (at least) threefold; to increase a learner's competence, confidence, and learning ability. The totality of the learning process should improve the learner's social ability to learn from the whole process on how to be able to have stylistic flexibility and, by that, use her learning

preferences to handle a test optimally, so her learning preferences make the best fit to the test. Here, we are focusing on introducing scoring techniques to assess a learner's competence concerning a specific subject from responses to different kinds of multiple-choice tests, thereby being able to provide autonomous adapted feedback within the constraints of increasing learner awareness of own learning style and strengthen confidence and learning ability. How a learner decides to act is essential for acquiring and maintaining satisfactory situational and learning style awareness. Therefore, information of the test and evaluation design should be provided to the learner during the learning process.

Chapter 2: Initial teacher education: Teaching observation oral feedback practices in the United Arab Emirates; by Sarah Hyde. School-based practice is widely recognised as a cornerstone of effective initial teacher education programmes, with mentor feedback playing a crucial role in student-teacher development. This action research study focuses on post-teaching observation feedback (PTOF), the discussions between mentors and mentees following observed teaching sessions. Conducted at an initial teacher education institution for Emirati women in the United Arab Emirates, the study examines and enhances PTOF practices from the perspectives of Emirati and expatriate college mentors, as well as Emirati student-teachers. Cycle 1 gathered insights through qualitative questionnaires and focus group interviews, informing a series of professional development sessions that produced new practice guidelines. Cycle 2 assessed the impact of these interventions, with data collected through interviews and focus groups. Thematic analysis was used to evaluate data from both cycles. Findings from Cycle 1 revealed significant inconsistencies in PTOF practices, while Cycle 2 indicated improved structure and consistency. To further enhance PTOF, the study recommends allocating more time and providing contextual developmental support.

Chapter 3: Developing pre-service teachers' praxis through a culturally and linguistically immersive teaching experience; by Wendy Ruchti & Cory A. Bennett. Being an effective educator within culturally and linguistically diverse schools requires a rich understanding of how to support students from various cultural and linguistic backgrounds. Historically, teacher education programs have not fully addressed strategies to leverage students' cultural identities and linguistic strengths. Pre-service teachers, particularly those from rural and homogeneous communities, often have limited exposure to diverse populations. However, classrooms today are increasingly global, with students speaking multiple languages and families embodying different cultural norms. To bridge this gap, learning about the intersection of school, community, and families from diverse perspectives is critical. This mixed methods study aimed to provide pre-service teachers with unique and practical experiences to prepare them for teaching students from culturally and linguistically rich backgrounds. Data were collected through daily reflections with open-ended questions and Likert-scale questionnaires. Qualitative data were analyzed using thematic analysis to identify recurring patterns, while quantitative

data were examined through descriptive statistical methods. Findings suggest that immersive experiences broadened pre-service teachers' understanding of diversity and equipped them with strategies to create inclusive learning environments. These results highlight the importance of experiential learning in preparing future educators for success in increasingly diverse classrooms.

Chapter 4: *The electronic gradebook alternative: The custom-made course administration spreadsheet*; by Brian G. Rubrecht. Instructors at all educational levels are responsible for a variety of course-centric administrative duties, which typically include taking attendance, planning lessons, marking and recording homework and other assignments, and calculating students' grades at the end of a semester. While many instructors are drawn to the numerous commercial and open-source electronic gradebooks available to aid with the implementation of such duties, they may only later realize their drawbacks, which can include their being time-consuming to learn, inflexible, inoperable after operating system upgrades, or insufficient in terms of certain desired features. There is no one-size-fits-all electronic gradebook solution, but the often-overlooked gradebook alternative that counters many of these drawbacks is the custom-made course administration spreadsheet. The present chapter seeks to illustrate through explanation and example the reasons and methods by which such spreadsheets can offer instructors effective and adaptable tools for handling their course-related administrative requirements.

Chapter 5: *Enhanced conceptualization of learning algebra through scientific-oriented teaching*; by Natalia Karlsson & Wiggo Kilborn. The purpose of this project is to analyze how the scientific concept of inverse operations can be used as a "bottom-up" approach for teaching mathematical operations with whole and rational numbers. The primary aim of the study is to provide support for teachers in the teaching of scientific mathematical concepts to students of algebra. The theoretical approaches applied in this project are the theories of mathematical structures, especially the theory of inverse semigroups (Abelian groups), and relational thinking, in a comparison with instrumental thinking. The methodological approach uses Vygotsky's doctrine of scientific concepts. The presentation of the analytical findings expands on previous research on additive and multiplicative inverses in teaching and conceptual learning of algebra. The findings illustrate how connections to mathematical structures and scientific concepts, such as the concept of inverse, lead to an understanding of algebraic operation rules for whole and rational numbers.

Chapter 6: *Teachers' views on infusing indigenous knowledge into chemistry teaching at the junior secondary of Omusati region*; by Tomas Asino, Kgomotsego Samuel, & Washington Dudu. This study focused on the views of Natural Sciences teachers in infusing indigenous knowledge (IK) in teaching of Chemistry concepts at the junior secondary school. IK remains an afterthought in many Omusati region classrooms especially at grades 8 and 9 level. This is despite

the National Curriculum for Basic Education promoting the inclusion of indigenous knowledge into teaching to empower learners to actively participate in making Namibia a knowledgeable-based society. Five grades 8 and 9 Physical Sciences teachers were purposefully selected from one circuit in the Directorate of Education, Arts and Culture of Omusati region, Namibia. Researchers employed an interpretivist qualitative research approach. This qualitative study used CHAT to understand the teachers' views and classroom practices through integrating IK in teaching of Chemistry. Saldana (2013) was used to guide thematic analysis of data. The findings indicated a slight change of views by the Physical Science teachers. Some remained attached to certain practices where they held strong beliefs. The infusion of certain Chemistry concepts depended on the school support. The study recommended that teaching and learning policies be clear on the 'how' of infusing IK into the classroom, and adequate support through ongoing developmental workshops be provided to the Science teachers.

Chapter 7: *Comparison of visual and phonological skills in dyslexia subtypes: Clinical and educational impacts*; by Giseli Donadon Germano & Simone Aparecida Capellini. The objectives of this study were to characterize and compare the visual, phonological and mixed subtypes of schoolchildren with an interdisciplinary diagnosis of developmental dyslexia. A total of 122 schoolchildren, aged between 8 years and 11 years and 11 months, from the 3rd to 5th year of Elementary School I in the public network, divided into groups, being GI (61 schoolchildren with an interdisciplinary diagnosis of dyslexia); and GII (61 schoolchildren with good academic performance), paired with GI in relation to the school year. All were submitted to Phonological Skills and Visual Perception Assessments. Factors were created for profile classification for GI, with dyslexics separated into phonological, visual and mixed profiles. The results indicated that there was significance for all comparisons between GI and GII. There was a significant difference between the GV and GPH groups; GPH and GM groups and Between GV and GM. The findings of this study allow us to conclude that schoolchildren with dyslexia can present visual defects regardless of the phonological one. These findings have clinical and educational implications.

Chapter 8: *Adapting to crisis: A case study in emergency online faculty development*; by Ashley Salter & Shelly Wyatt. The University of Central Florida (UCF) shifted to remote online instruction during the Spring of 2020 due to the COVID-19 pandemic, revealing gaps in faculty development for online teaching. This case study examines how UCF utilized its online pedagogy expertise and resources to create an emergency faculty development program. Through semi-structured interviews and document analysis, five key themes emerged: leadership challenges, reliance on existing resources, implementation barriers, foundational LMS tutorials, and strategies for diverse faculty needs. Findings showed that instructional designers adapted resources rapidly, defined training objectives, and supported faculty engagement despite challenges like departmental resistance. The study compared

UCF's approach to those of other institutions, highlighting common issues such as tight timelines, diverse faculty needs, and effective practices like peer mentoring and data-driven design. The study concludes with recommendations for improving emergency faculty development programs, focusing on modular training, leadership support, peer collaboration, and accessibility. It offers valuable insights for institutions seeking to build resilient and inclusive faculty development frameworks for future emergencies.

Chapter 9: *Understanding of pre-service teachers' mathematical knowledge and perceptions of teaching*; by Natalia Karlsson & Wiggo Kilborn. The objective of the present study is to analyze pre-service teachers' mathematics knowledge base as a relationship between their substantive subject mathematics knowledge and syntactic subject mathematics knowledge. The theoretical approach refers to Shulman's pedagogical content knowledge and Ball, Thames and Phelps' subject matter knowledge for the teaching concept. The participating pre-service teachers (PSTs) were divided into two groups: 20 from a program course for K–3 teachers and 25 from a program course for grade 4–6 teachers. The crucial mathematical content for the study was algebraic patterns, rational numbers (fractions), proportionality and elements of combinatorics. The findings show the importance of gaining a better insight into and understanding of student teachers' learning process and challenges related to the mathematics knowledge base (e.g., its substantive and syntactic components). The benefits of the empirical findings are that they led to new knowledge and a deeper understanding of PSTs' learning of mathematical concepts through two learning processes (SUB and SYN), as well as the relationship and shift between these processes.

Chapter 10: *Assessment of numerical cognition in Brazilian preschoolers - Elaboration and study pilot*; by Silvia Cristina de Freitas Feldberg, Rita dos Santos de Carvalho Picinini, & Simone Aparecida Capellini. During the preschool years, the main difficulty that can predict the risk of mathematical difficulties is the delay in the ability to learn quantities associated with number words and Arabic numerals. Objective: to assess numerical cognition for Brazilian preschoolers aged 2 years to 5 years and 11 months old. Methods: Based on a literature review, mathematical skills were selected to evaluate numerical cognition. A pilot study was conducted to verify the applicability of the developed instrument in 74 Brazilian preschoolers (44 boys) from public municipal early childhood education in the city of São Paulo, Brazil, distributed in the following age groups: Group I: 15 preschoolers, aged 2 years to 2 years and 11 months old; Group II: 18 preschoolers, aged between 3 years and 3 years and 11 months old; Group III: 19 preschoolers, aged between 4 years and 4 years to 11 months old; and Group IV: 22 preschoolers, aged between 5 years and 5 years to 11 months old. Developing an instrument to assess numerical cognition in preschoolers can contribute to developing logical-mathematical reasoning in these children, helping teachers develop activities and games that teach basic numerical, contributing to future gains in mathematics learning.

Chapter 11: *Absence-presence in the production of 'green' schools*; by Tanaya Vyas & Girish Dalvi. Schools are increasingly involved in the production of 'green' artefacts, installations, and activities. However, school discourse rarely features design processes and negotiations related to school 'greening'. What does it mean for schools to become 'green'? This chapter offers a critical examination of school 'greening' beyond its pedagogical purpose, particularly through tracing logics underlying production and consumption of tree-based installations in government primary schools of suburban Mumbai. Participant observation, and go-along conversations with school members reveals an image of a 'green' school, as an intense version of reality. The schools bear 'presence' of trees in absence of actual trees in or around their campus, through crafting site-specific displays. The discussion articulates how 'green' schooling is projected as a prospective remedy for many issues. The desirability of the hyperverdant projections seems to rest on the seemingly liberating, yet normative discourse of 'mending'. Analysis of school production concludes that, despite their apparently subversive character within educational conventions, the 'green' imaginings inadvertently reinforce the very norms they seek to challenge. This could result in school members negotiating paradoxical expectations. Implications are discussed with regard to new ways of thinking about school design research in the context of Environment Education.

Chapter 12: *A transformative instruction model and task-oriented learning*; by Natalia Karlsson & Constanta Olteanu. This study is analytical research that examines a theoretical approach to transformative pedagogy (TP) and transformative learning (TL) in order to conduct a logical deductive construction of the transformative instruction model (TI model). The study aims to enhance the understanding and effectiveness of the interplay between teaching content and learning in the form of requires for the high-quality teaching of students in the cognitive development of mathematics. It also analyzes the conditions for transformative teaching and learning in a task-oriented context. The crucial psychological outcomes focus on the domains of TP and their interpretation within the context of Mezirow's TL theory, emphasizing an instrumental, dialogic and self-reflective learning discourse, as well as meaning schemes in learning. The methodological approach is based on a systematic deductive analysis. The analytical results as a conceptualization and an analytical construction of a TI model related to transformative teaching and learning algebraic concepts. The TI model is the result of extending theoretical approaches to TP and TL, as well as logical connections to research about the formation of algebraic concepts. Benefits of the TI model is a new knowledge about an effective teaching of algebra, where students' algebra learning, and knowledge development is crucial.

Chapter 13: *Psychosocial skills, emotional understanding and resilience related to attachment in young people*; by Eva Vancu. Adolescence is a stage of development of psycho-social skills through training and education. The goal of our research is on

the bases of scientific theory and empirical research assemble psychoeducational methodology for development of emotional regulation and resilience of students and adolescents. The sample consisted of 367 adolescents. The respondents completed questionnaires The Child and Youth Resilience Measure, modified version of Situational Test of Emotional Understanding and a questionnaire of trait emotional intelligence. To obtain the results, we used a battery of questionnaires, which consisted also of IPPA-R questionnaire designed to measure the quality of the attachment to the mother, father and peers. The results have shown that adolescents in middle adolescence have lower rates of emotional regulation and resilience. We found out that the quality of the attachment influences the effectiveness of emotional regulation of adolescents. Our results also show that adolescents usually form a secure attachment in their relationships. We also found out that they form the least quality with their fathers and the most quality relationship with their peers.

Chapter 14: *Teachers' challenges navigating the provision of support to learners with special needs: Mainstream rural school perspective*; by Omphile Tshepo Cooperate Madiba & Appolonia Masunungure. Implementing support to learners with special needs in South African schools has largely been presented with challenges which increasingly make it difficult for teachers to navigate their provision of support. Thus, the pragmatic realities show that there is a need to identify and combat such challenges. This study investigated challenges experienced by teachers in their attempt to support learners with special needs. The study is underpinned by the social constructivism paradigm. The study used the transformative learning theory. The phenomenological qualitative research approach was employed to explore teachers' challenges in providing support to learners with special needs in mainstream rural schools. Data were collected using focus group interviews, with 36 purposively selected teachers in 6 schools. The collected data was thematically analysed and interpreted using Braun & Clarke methods. The study discovered the following as challenges hindering the provision of support to learners with special needs: lack of competency in managing the diverse learning needs of learners; limited resources; as well as a lack of training in attending to learners' learning needs. The study recommended resource allocation, teacher professional development training, and initiation of collaborative networks, to be in place for the alleviation of the support challenges experienced by teachers.

Chapter 15: *Teachers' attitudes in multicultural schools in Athens - A pilot study*; by Kendra Macris & Despina Paizi. Greece stands as the 'gateway to Europe', embracing waves of refugees and immigrants from diverse corners of the globe over the past three decades. Consequently, the educational landscape is undergoing a profound transformation, as students representing a kaleidoscope of backgrounds attend school in Greece. However, teachers are often left grappling with the challenge of adapting to this vibrant mosaic of diversity without support. This pilot study aimed to investigate the attitudes of twenty four teachers that attempt to navigate this multicultural milieu in three elementary schools in a highly

concentrated multicultural area of downtown Athens. A survey was employed to assess how teachers' awareness of the challenges that multicultural and multilingual students face influence their ability to use adept teaching strategies. The results indicate that the more teachers are aware of these challenges, the more teaching strategies they employ. The findings also show that they feel unsupported in their efforts to bridge the cultural chasms between themselves and their students of varied backgrounds. Based on these findings this pilot study explores how teachers could be effectively supported by means of teacher training seminars targeting key areas of multicultural education.

Chapter 16: *Reflections in acceleration: How GenAI technologies impact educational practice*; by Stine Bylin Bundgaard, Susanne Dau, Camilla Gylvendahl Jensen, & Camilla Finsterbach Kaub. In an accelerating world where generative artificial intelligence (GenAI) significantly influences the daily operations of education, it is pertinent to discuss how this format can be integrated to balance and support students in working reflectively with the complex array of available knowledge and its interconnections. This chapter will explore the future of education through the lens of reflective practice learning, proposing how higher education can be reimaged to embrace GenAI as an opportunity to develop reflective competence. The discussion is grounded in Hartmut Rosa's (2021) mapping of the accelerating society, Donald Schön's work on reflection and learning (1991; 1990), and Hannah Arendt's elaboration on professional judgment. The chapter argues that future education must increasingly support the development of students' ability to learn how to learn and their capacity to critically reflect in their qualification of actions.

Chapter 17: *Strategies for developing mathematics and science resilience in pre-service teachers to address maths and science anxiety in South African schools*; by Sakyiwaa Boateng. This chapter explores strategies to foster resilience among pre-service mathematics and science teachers education to reduce maths and science anxiety within South African schools. Pre-service teachers often face high levels of maths-science-related anxiety, which can impact their effectiveness and confidence in teaching these subjects. Developing resilience is crucial to helping them cope with the challenges of teaching. This project examines various resilience-building strategies and practical teaching experiences and the integration of anxiety-reducing techniques within teacher training curricula for mathematics and sciences. The Self-Determination Theory underpins this study. The study employs a participatory action research approach, collecting qualitative insights from focus group interviews and reflective journals. This study employed action research to design cycles of whole class (n=29) intervention based on three tools designed by Johnson-Wilder and the mathematical resilience network team, and the emotional grid to support pre-service teachers in building resilience in math/science as they prepare for fieldwork. Data was analysed through thematic content analysis. The findings revealed that maths/science anxiety may be successfully reduced through

the effective use of emotional tools. These findings suggest a new method of utilising the affective domain in teachers' training in South Africa for educational transformation.

Chapter 18: *Leveraging ICT tools for teaching and learning in physical sciences*; by Sam Ramaila. This chapter examines the effective use of Information and Communication Technology (ICT) tools to enhance teaching and learning in physical sciences. By incorporating various ICT resources—such as simulations, virtual labs, and interactive multimedia—the chapter evaluates their impact on student engagement, comprehension, and academic achievement. Through a mixed methods approach, the study identifies optimal strategies for integrating ICT into pedagogical practices, particularly for deepening students' understanding of abstract scientific concepts. The study's findings reveal that ICT tools, such as simulations and interactive demonstrations, significantly improve students' grasp of complex concepts by providing visualizations and hands-on experiences. Participants reported increased engagement and comprehension, with ICT-enabled personalized learning allowing students to progress at their own pace and access supplementary materials. Despite these benefits, challenges persist, including limited access to technology, insufficient technical support, and concerns over digital equity. The chapter concludes by offering actionable insights for educators and policymakers seeking to enhance physical sciences education through ICT integration while addressing the systemic barriers that hinder equitable implementation in diverse educational contexts.

Section 2, entitled “Projects and Trends”, presents chapters concerning, as the title indicates, education viewed as the center for innovation, technology and projects, concerning new learning and teaching models.

Chapter 19: *Barriers to flipped classrooms in South African universities: Context and content challenges*; by Thuthukani Dlamini. A significant shift in pedagogical methods is the adoption of the Flipped classroom approach. This method challenges direct instruction as the most efficient use of class time. Instead, it encourages students to engage with new material before coming to class, reserving class time for activities that foster higher-order thinking and activity. While this strategy addresses limited classroom time, it often overlooks the complexity and cognitive demand of module content, as well as the socio-cultural contexts within South Africa's diverse higher education landscape. This qualitative research investigates the challenges associated with implementing the Flipped classroom model within South African Higher Education. Using a case study approach, data was collected through questionnaires with South African University students to assess the influence of their community backgrounds. Additionally, semi-structured interviews with a lecturer were conducted to evaluate cognitive demands and support needed for this instructional approach. The findings reveal that the community contexts, combined with the cognitive challenges posed by module content, significantly impede the

successful implementation of the Flipped classroom model. The study recommends that South African universities prioritize community engagement initiatives that foster supportive learning environments and invest in university residences equipped with the necessary infrastructure and academic support.

Chapter 20: *What chatbot should support novice instructors in assisting students in PBL practice*; by Akiko Kai, Yuriko Ishida, & Ryuichi Matsuba. "Reflection-Bot" is a chatbot originally designed for daily journaling in self-directed language learning, with features that promote goal setting and reflection through personalized notifications. In the present paper, we explore the potential of utilizing this chatbot for students' weekly learning supports in a PBL course through an analysis of interview data from several new instructors. The results highlight various issues with the PBL course as currently practiced, such as inadequate instructional time for students, lack of intervention training for instructors, and underestimation of the importance of intervention. We show that if we add to the existing chatbot the ability to intervene for students' learning on behalf of instructors or to show instructors how to do that could potentially solve some of the issues.

Chapter 21: *Strengthening the university-company partnership - A collaborative design project*; by Xiaozhu Lin & Matteo Oreste Ingaramo. On a global scale, universities today are increasingly expected to enrich their curriculum with real-world learning experiences to increase student engagement and cultivate students' critical social competencies. The topic of collaboration between universities and companies has been extensively debated, and there is a widespread acceptance of the notion that companies can genuinely contribute to teaching content by sharing cutting-edge knowledge, expertise, and resources. In this chapter, the authors examine the discrepancy between universities and companies in the design field to identify viable strategies to enhance collaboration between these sectors. The authors provide a design project conducted in partnership with a prominent global company as a case study to illustrate the effectiveness of such initiatives in closing the gap between universities and companies. The authors aspire to furnish fellow researchers in cognate fields with a valuable reference point, informed by the experiences gained from this project, to explore further and enhance design practice, achieving more substantial and consequential outcomes.

Chapter 22: *Digital and analogue gaming in the daily lives of people with intellectual disability - A case study in the Portuguese context*; by Carla Sousa & José Carlos Neves. The role of games in promoting cognitive and social development for People with Intellectual Disability (PwID) is increasingly recognised, yet the specific impacts of digital versus analogue games remain underexplored. This study explores the cognitive, social, and emotional influence of digital and analogue games on PwID in Portuguese institutions. Using a participatory design approach, four games – two digital and two analogue – were developed collaboratively between academia and self-advocacy institutions. Semi-structured

interviews were conducted with support workers from two institutions in the North of Portugal, who provided feedback based on their experiences of using these games with PwID. Thematic analysis of these interviews identified key themes such as cognitive skills development, social interaction, accessibility challenges, and game design preferences. Results indicate that both digital and analogue games can promote cognitive stimulation and social engagement, though analogue games tend to foster richer peer interaction, while digital games are associated with maturity and autonomy by the participants. The study highlights the importance of customisation and accessibility in game design and suggests future research should focus on longer-term effects.

Chapter 23: *Ecodesign as an innovative approach to teaching in secondary schools*; by Tetjana Tomášková, Daniel Duda, Jan Krotký, & Jarmila Honzíkova. The main objective of this chapter is to provide a new tool for teaching technical subjects in secondary schools. Specifically, it is ecodesign as a systematic process of designing and developing a product, which, in addition to features such as functionality, safety, technical feasibility, etc., places great emphasis on achieving a minimal negative impact of the product on the environment, mainly from the point of view of the life cycle. The introduction to the chapter describes the product manufacturing process as a system that is managed with respect to the environment. The next part of the chapter summarises the theory on the integration of environmental aspects into the product design process using the ecodesign methodology. In conclusion, the chapter compares metal and plastic 3D printed products and considers the usual requirements for product properties such as functionality, quality, safety, price and appearance. The connection of ecodesign and environmental management systems is an effective implementation of a preventive approach to the identification of risks of products, activities and services and the subsequent setting of preventive measures, which will clearly show the students the importance of Ecodesign as a tool.

Chapter 24: *Online education in Latin American higher education: A systematic review*; by Salvador Antelmo Casanova Valencia, Arcadio González-Samaniego, Bertha Molina Quintana, & Rigoberto López Escalera. COVID-19 forced higher education institutions to implement virtual education activities without being prepared for it, representing a challenge for the traditional model. This has been exacerbated in Latin American institutions, as they do not have adequate resources and infrastructure. The objective of the study was to identify trends in online education research in Latin America because of the health emergency. To achieve the objective, a systematic literature review was carried out. Documents published in Scopus between 2008-2023 were analyzed using the Biblioshiny and VOSviewer software. 47 documents were found, of which 40 were published in the period 2019-2023. Keywords were analyzed according to their co-occurrence. 376 documents were found and 47 with a minimum of two co-occurrences were selected. The documents have been associated in four clusters. The results show the impact on university education during and after the pandemic in Latin America. Online

education has continued after the pandemic, exploring new forms of learning. It has enabled access to higher education for sectors of the population that traditionally could not join it, due to issues such as geography and economics. Challenges are noted in creating infrastructures and processes that allow promoting this type of teaching.

Chapter 25: *The importance of the role of professional socialization for educators as they encounter innovation in curricular and artificial intelligence technology*; by Ekaterina Kozina, Marie Hyland, & Catherine Comiskey. Teachers throughout their professional lives and their career experiences have long been the focus of educational research. Educators at all levels, including primary, secondary schooling, and tertiary education, are faced with increasingly complex demands placed on them by society, expanding role of education, curriculum reforms, the increasing use of Artificial intelligence technology in the classrooms, and diverse environments in which teachers work. It is recognized that teachers' professional experiences encountered during their early years of professional practice and their first teaching year, also known as an induction year, has far reaching implications for teachers professional learning, development as well as their subsequent teaching career. Consequently, teacher professional socialization and retention in the profession to a large degree depend on professional experiences encountered in their working environments during early teaching years.

Chapter 26: *Views of learners on transforming schools into more inclusive spaces*; by Thabo Makhalemele, Rachel Rirhandzu Mayimele, & Pateka Pamella Jama. Inclusive education has gained prominence as an essential educational approach throughout the world. In the South African context, inclusive policies recommend the active participation of learners in the education process to develop and extend their potential as equal members of society. This study explores the perceptions of learners regarding inclusive education and its potential to improve teaching practices. This participatory research study, using transformative learning theory as a lens will employ photovoice and narratives. The participants were 25 full-service school learners in Gauteng and North-West Provinces of South Africa. Thematic data analysis was used to analyse the data. The study findings revealed that learners do not have a voice in the implementation of inclusive policies; only teachers are privileged to influence inclusive teaching, while learners are only expected to be recipients, and that learners are treated as empty vessels. Although the study has found that learners are disadvantaged in contributing to inclusive practices, it recommends an integrated approach among teachers, learners, and education policy developers to ensure that learners' voices are heard in schools to improve inclusive teaching practices.

Chapter 27: *Personalizing learning through collaborative networks of knowledge*; by Ralucca Gera, Mark Reith, D'Marie Bartolf, Simona Tick, Paolo Singh, Sean Mochocki, & Akarti Saxena. Over the past two decades, numerous learning systems have emerged promising novel approaches to improve education and

training. However, most rely on exposure to information and practice, which does not guarantee the internalization of the concepts and changes in behavior required to engage the learner appropriately in education and training. This paper presents a new learning process that addresses these limitations by modeling, motivating, guiding, assessing, and attesting the learner. We present each of these steps and discuss how leveraging innovative knowledge structures using network science, emerging technologies, and AI, can support the proposed learning system that engages learners in their learning journey. The system's effectiveness is illustrated through two pilot studies on two different learning systems, a process that integrates: (i) a theoretical framework developed based on data on student learning and (ii) on student and faculty experience undergoing years of testing and refinement based on faculty expertise and learners' experiences, shaping the systems' designs and outcomes.

Chapter 28: *Fostering scientific thinking in primary students through investigative environment*; by Valentina Bologna & Caterina Bembich. The Agenda 2030 objectives highlight the need to engage students in STEM (Science, Technology, Engineering, and Mathematics) to support ecological and cultural transitions. Understanding students' scientific thinking involves examining their social, cultural, and environmental contexts. Inquiry-based learning is an effective teaching strategy that promotes exploration and develops scientific reasoning. This work presents preliminary findings from a case study testing innovative teaching methods to inspire primary school students in STEM. In the first phase, a class of final-year primary students participated in a hands-on physics activity using an inquiry-based approach. Observations indicated that the activity improved reasoning flexibility, encouraged collaborative learning, and increased motivation and engagement.

Chapter 29: *Towards a framework to support novice teachers in rural areas: Implications for blended professional development initiatives*; by Nomfundo K Radebe & Emmanuel Mushayikwa. Research indicates that teacher professional development significantly influences teaching practice. The widespread adoption of online and blended modes of professional development that occurred in response to the COVID-19 pandemic was expected to enhance access to professional development for teachers in remote and rural areas of South Africa. However, research on the use of blended professional development in these settings remains limited. This study addresses this gap by employing a qualitative approach to examine the key components of a blended teacher professional development intervention in a rural area. Data was collected using classroom observations, interviews, and field notes and was analysed thematically. The study identified several components that contributed to the effectiveness of the intervention: sustainability, content focus, coherent, access to digital tools, active engagement, longer duration, individual support, and collaboration. The study also underscored the importance of facilitators of blended professional development possessing Technological Pedagogical Content Knowledge (TPCK) competency.

Chapter 30: *Students' use of learning videos*; by Bjarte Pollen, Joar Sande, Lars Kyte, Per Eilif Thorvaldsen, Sven-Olai Høyland, Erlend Raa Vågset, & Marcin Fojcik. As digital learning grows, understanding student engagement with educational videos is essential, yet few quantitative studies exist within Norwegian educational research. This study addresses that gap by surveying over 1,400 Western Norway University of Applied Sciences (HVL) students with 252 responses to explore their video preferences, viewing habits, and perceived benefits. Results show that, while students rate external videos from elite institutions higher in technical quality, they still prefer videos made by their lecturers over hybrid teaching videos. Academic relevance stood out as the most important factor, with content quality prioritized well above other considerations like pedagogical approach, video length, and technical features. Students use videos as a general learning aid throughout the semester, not just for exam preparation, and prefer videos to be available before class, supporting flipped classroom methods. These findings suggest that educators focus on creating accessible, content-centered videos aligned with course needs to enhance student engagement and learning outcomes.

Chapter 31: *Innovative education and life cycle assessment of 3D printed products*; by Tetjana Tomášková, Daniel Duda, Jan Krotký, & Jarmila Honzíková. The chapter is devoted to life cycle assessment, specifically determining the carbon footprint of a product produced with the help of a 3D printer. At the beginning of the chapter, mind maps are described that relate to a specific product printed on a 3D printer, which has clearly defined goals: to describe the individual phases of the product's life cycle; orientate yourself in concepts related to product quality; define product life cycle costs; assess the impact of various factors on product quality; to evaluate the impact of production using a 3D printer on the environment. There are various calculators for calculating emissions, which, after filling in, will evaluate the result. However, it is often impossible to look at how the process was calculated to know how a particular value arrived at. Calculations were calculated in Microsoft Excel, where clear methods of calculation were presented to the students. At the end of the chapter, there are recommendations for applying the sustainable development of active learning methods to teaching.

Chapter 32: *An Afrocentric approach to analysing literary text through African values in English first additional language*; by Thuthukani Dlamini & Eugene Marais. Literature and culture have an interlinked relationship, and prescribed literature texts have a fundamental role in ensuring that these coexist harmoniously. Centralising African Values in prescribed literature should be prioritised in South African classrooms, to achieve the nationally aspired decolonised approach to education. This paper explores the teaching of these African Values in prescribed literature, particularly short stories. This qualitative study uses textual analysis to generate data with the Afrocentric paradigm as the conceptual underpinning for the study. Reviere's (2001) Afrocentric canons show how African values can be taught. The paper presents the context, methodology and doctrinal underpinning of Afrocentrism before using Afrocentrism as a tool to analyse a text.

We also look at the functions of texts for young adults to distinguish ideological purpose and as a vehicle for transmitting cultural values. The paper recommends that teachers and learners be conscious of these Afrocentric values and their impact on literary analysis in South African classrooms.

Section 3, entitled “Teaching and Learning”, offers research about foundations in the education process itself, in various contexts, both for tutors and students.

Chapter 33: *Developing emotional literacy, support of emotion regulation and psychological resilience in the context of learning programs*; by Eva Vancu. The chapter presents the main findings of a research project aimed at methodology for developing and strengthening resilience and emotional literacy for teachers. The aim of this thesis is to find out what are the needs of today's teachers in the area of emotional literacy and the appropriateness of applying the proposed training programme. In the theoretical section, the concepts of emotion, emotion regulation, social skills and communication, resilience and their relevance to the profession of teachers are explained. The training programme is developed for continuous training of teachers in the form of presentations. The outputs of the project include an empirically validated, theory-based methodology manual for teachers to strengthen their psychological resilience. Teachers' practice and experience indicate a strong need for further training in the area of emotions and emotion management. After completing the training programme, the teachers' expectations were met and they expressed their satisfaction with the implementation of the emotional skills training and the promotion of their self-development. The programme was designed to stimulate teachers' interest in further exploring ways of learning. In the future the preparation of webinars for the acquisition of the methodology in the form of a short-term training programme for teachers using e-learning.

Chapter 34: *How do students manage challenging study tasks? A thematic analysis of higher education students' (non-)strategic study-related behaviors*; by Diane Marcia Manuhuwa, Simone Hanegraaff, Johanna Schönrock-Adema, Sjoerd J. de Vries, Jan Willem de Graaf, & Joke Fleer. Higher education presents students with numerous challenges, requiring effective use of executive functions (EFs) to navigate academic demands. EFs are higher-order cognitive processes that regulate thinking, behavior, and emotions for goal-directed and adaptive actions. While strategic behaviors can optimize EFs, students also adopt routines or habits (non-strategic behaviors) to manage study tasks. This study explores students' (non-)strategic behaviors and which EF they predominantly support. Twenty-three students (aged 17-26) were interviewed at a Dutch University of Applied Sciences. Subsequently, we identified 27 themes and 89 types of (non-)strategic behaviors linked to nine EFs through inductive and deductive thematic analyses. The findings provide insights into which specific (non-)strategic behaviors support EFs. This helps students and educators identify behaviors that can strengthen particular EFs, especially those that may be underdeveloped and offers input for guidance for more targeted educational interventions to improve learning and studying.

Chapter 35: *The challenges of learning tasks from the perspective of children from marginalised Roma communities*; by Mária Hušlová Orságová, Katarína Vančíková, & Marián Trnka. Slovakia is a country of permanent or temporary residence for many nations and ethnic groups, which oftentimes do not have the possibility to receive education in their own language. One of the most controversial linguistic minorities on this front are children from the Roma community, which are commonly marginalised due to different living conditions as well as socio-economic standards. Both these factors highly contribute to segregation of Roma children from the Slovak majority and negatively affect their cultural experience. When entering the formal education system, Roma children do not possess the same linguistic competence of Slovak language as pupils from the major population. In this paper, the authors analysed the textbooks in Slovak: commonly used in the first two grades of elementary schools and attempted to identify the most frequent words, phrases and sentences that children from the Roma community usually encounter in written form, while being educated. By doing so, the authors would like to increase their potential comprehensibility for pupils from marginalised Roma communities. The findings of this research provide a basis for the development of an effective language programme for the second language acquisition of Slovak and urges the Slovak school system to develop a comprehensive national strategy, which would provide adequate language support for children from linguistic minorities.

Chapter 36: *Understanding the learning space: A bibliometric analysis on blended learning in higher education*; by Thoko Poppy Mahlangu. Learning in higher education was predominantly the traditional face-to-face type of learning. Blended learning has been adopted as the relevant approach to teaching and learning, based on the lesson learned during the COVID-19 period. The concept “learning space” refers to a full range of spaces in which learning occurs, from real to virtual learning, and from the classroom to chat rooms. Blended learning necessitates an understanding of the learning space and design, pedagogy and curriculum, and their relation to the learning space. The learning space is critical for the realisation of learning outcomes. Online learning cannot replicate everything of value in the face-to-face experience of learning. The reflection on the blended learning approach is guided by the conceptualisation of learning as acquisition, learning as participation, and learning as knowledge creation. This study reflects on trends in blended learning (between 2013 and 2024), as aided by an extensive literature review. A qualitative methodology was employed, and data was analysed using the bibliometric analysis. This chapter discusses the effects of blended learning on students. This study is significant as it helps improve lecturers’ implementation of blended learning, which would translate into developing essential online and face-to-face learning pedagogy, as institutions of higher learning globally have adopted blended learning.

Chapter 37: *Project-based teaching - Insights from development in teaching in construction management*; by John Lindgren & Anna Isaksson. Future engineers must be fluent in different technologies, methods, and methodologies requiring a

high dynamic capability, in opposite to many students' behavior. Project Based Learning, student-centred with a dynamic approach to teaching where students study real-world problems and challenges, aims to increase dynamic capability. This research reports transforming a course in construction management into a project-based approach to stimulate students' intrinsic motivation, i.e interest in what is learned and the pleasure it brings. Course material has been developed in four rounds, ranging from 2022-2024. Course documentation regarding the execution of the course as well as documented student feedback was thematically reviewed and analyzed relation to the aim of this chapter. The development shows interesting challenges in teaching regarding the balance between showing results from the actual project vs. stimulation of creativity among students. Age and work experience positively affect how the students execute the projects. It also shows the significance of the course framing and variation of project set-ups. Our findings also show values in PBL for students' ability to handle changes in a world with many insecure influences and it is indicated that PBL requires a learning process over time both for students and teachers.

Chapter 38: *Exploring the support needs of teachers in full-service schools to promote inclusion*; by Matabe Rosa Modiba & Appolonia Masunungure. Supporting teachers in full-service schools (FSSs) is important in the South African education system as it enhances education for sustainable development. Although teachers have undergone pre-service and in-service training as part of support in inclusive education, it is apparent that they do not receive adequate support to teach in inclusive classrooms. Entrenched within the qualitative approach and the interpretivism paradigm, the study allowed teachers to construct reality in terms of their support needs. 12 participants from two full-service schools in the North-West Province were purposively sampled. Data were generated through semi-structured interviews and were thematically analysed. The findings indicate that continuous practical training is their key need for support. Availability of the teaching and learning resources, participation in Professional Learning Communities (PLCs), and intentional support by the support structures were highlighted as other support needs of teachers in full-service schools. In addition, adequate collaboration with the key learning support stakeholders was highlighted as a support need in inclusive education settings. It is recommended that the School Management Teams (SMTs), School-Based Support Teams (SBSTs), and District-Based Support Teams (DBSTs) should ensure that teachers are trained theoretically and practically on a continuous basis to maintain inclusive pedagogies.

Chapter 39: *Screening for mathematical difficulties: Elaboration and pilot study*; by Rita Picinini, Simone Aparecida Capellini, & Giseli Donadon Germano. In Brazil, there are few studies about identification and early intervention of difficulties in mathematics. Objectives: To develop a screening tool to identify students at risk for mathematical difficulties in the initial literacy series and to verify the applicability of the screening elaborated. Methods: From a bibliographic survey, 8 mathematical skills were selected based on the Triple Code Model to elaborate a screening program

composed of number sense, number line, place value, addition, subtraction, multiplication, division and problem-solving skills. The screening was applied in four 45-minute sessions, twice a week, during class time. A total of 201 students from the 1st and 2nd grades of elementary school were evaluated. Of these, 44 students were identified as at risk and referred to the remediation program. The study showed the need to reduce the number of skills to 5: number sense, number line, place value, addition and subtraction. This reduction occurred due to the observation that knowledge related to addition and subtraction should be developed first. Conclusion: The adjustments made based on the results of the pilot study will favor the application of the screening to better identify students with difficulties in mathematical skills.

Chapter 40: *Active learning methods in anatomy teaching for operating room nursing*; by Lars Kyte, Grethe M. Dāvøy, Geir Egil Eide, & Alisa Rysaeva. Several studies have shown the benefit of drawing when learning anatomy. Virtual Reality (VR) also appears to be useful when learning about anatomical structures. This study aimed to describe how students in a master study programme in operating room (OR) nursing perceived the combination of drawing and the use of VR in the learning of anatomy. Constructivism and a sociocultural view of learning constitute a foundation for applying these active learning methods. The two methods were combined in a class of 29 students. The students were provided half-finished drawings of anatomical structures that they were to complete with guidance from the teacher. They also were to find various anatomical structures by using VR technology. A paper questionnaire was applied to evaluate the teaching programme. Data were analysed statistically (check-off questions) and descriptively (open-ended questions and comments field). Twenty-eight students (96.6%) completed the questionnaire. The students highly appreciated both learning methods. They reported that drawing made them work more actively during lectures and increased learning outcomes. They also perceived that the use of VR technology increased their understanding of the location of anatomical structures. The combination of drawing and VR technology appears to offer significant benefits to OR nursing students when learning anatomy, by both increasing student engagement and enhancing their understanding of anatomical structures.

Section 4, entitled “Organizational Issues”, gives a glance on tools for implementing organizational learning and change in the education context.

Chapter 41: *Facilis Descensus Averno - Or effects of interactions between own PhD research project and other projects initiated within university*; by Cezar Scarlat. This chapter is focused on PhD research projects in a large university, aiming to analyse the effects of their interactions with other organizational projects of the university. Assuming that objectives of doctoral research projects are aligned to the strategic objectives of the university, there were a few research questions, specific to this explorative study: How could the effects of interactions be measured? Are the effects of interactions always positive? If the effects of interactions are negative, then

which might be the reasons behind them? Ultimately, are there any solutions to avoid or mitigate the negatives? The study includes both secondary research (literature survey) and primary research: directly observed and personally experienced doctoral projects in a Romanian university environment under scrutiny, completed with semi-structured interviews with doctoral students. This piece of work reveals novel types of inter-project conflicts within higher education institutions, and findings allow the formulation of several recommendations, which are critically important to doctoral schools and PhD supervisors as well as to major stakeholders: higher education leaders and strategists, policy and decision makers, administrators and research managers. Alignment of objectives is essential.

Chapter 42: *Incrementa Atque Decrementa...Managing the university research centres along their lifecycle: Three cases and a common administrative issue*; by Cezar Scarlat. This chapter raises a specific question: Is there any common reason behind cases of failure encountered in higher education research centres or laboratories? The purpose is to launch a discussion about reasons behind unexpected failures of some university research units, with the objective of identifying possible administrative and management causes, possibly a common reason (either internal or external). As methodology, the study is qualitative, using both secondary (literature review) and primary research (empirical investigations). The method (observation) used three case studies (i.e. university research centres that failed). They were directly observed and/or personally experienced instances in the Romanian university environment – over a relatively long period of time (1980s–2000s). The empirical data were analysed through the lens of the organizational lifecycle. Regardless of their diverse age and size, mission and profile, and phase of growth in their lifecycle, administrative decisions were found as common type of cause of ending the activity in each case explored. The concluding remarks are focused on a set of recommendations centred on the main findings – to be recommended to the stakeholders: higher education policy makers, administrators and research managers.

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Section 1

Teachers and Students

Chapter # 1

ON SCORING COMPETENCE

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ABSTRACT

The overall objective of any learning process is (at least) threefold; to increase a learner's competence, confidence, and learning ability. The totality of the learning process should improve the learner's social ability to learn from the whole process on how to be able to have stylistic flexibility and, by that, use her learning preferences to handle a test optimally, so her learning preferences make the best fit to the test. Here, we are focusing on introducing scoring techniques to assess a learner's competence concerning a specific subject from responses to different kinds of multiple-choice tests, thereby being able to provide autonomous adapted feedback within the constraints of increasing learner awareness of own learning style and strengthen confidence and learning ability. How a learner decides to act is essential for acquiring and maintaining satisfactory situational and learning style awareness. Therefore, information of the test and evaluation design should be provided to the learner during the learning process.

Keywords: assessments in education, scoring competence, multiple-choice tests.

1. INTRODUCTION

During the last decades learning has again become a key topic. This time not only at learning institutions, but also in political and economic contexts. One reason for this is that a high level of competence (i.e., knowledge, understanding, and/or skills) in nations, organizations and individuals are considered both a necessity and a crucial competitive advantage in the present knowledge society and the reglobalized market (Aarset & Johannessen, 2022).

The overall objective of any learning process is (at least) threefold. It is to increase a learner's competence, confidence, and learning ability to improve the learner's ability for analytical and critical thinking and social skills, and thereby preparing them for society (Aarset & Johannessen, 2022).

Here, we are focusing on introducing scoring techniques to assess a learner's competence with respect to a specific subject from responses to assessments, for thereby being able to provide adapted feedback. Such an assessment is thus a quantitative or qualitative estimate of the competence level of the learner. For this being successful, the assessment score should, as close as possible, correspond to the "true level" of competence. How to measure this competence has for ages been discussed and debated without any clear conclusion being accepted in the literature, though.

A learner's understanding of her own learning process and her own competence (i.e., her situational and learning style awareness), will control her attention and influence how she decides to act. By learning style awareness, we mean the conscious dynamic reflection of the learning process by an individual learner. Situational awareness is often understood as a summary, a mental "picture", of what's going on in our world, and by some,

also including the process of acquiring this summary (Salmon, Stanton, Walker, & Jenkins, 2009). People make bad judgments when their overall understanding of what's going on is insufficient. This goes also for the learning process.

To acquire and maintain satisfactory situational and learning style awareness during a learning process, feedback to the learner needs to be provided. For this feedback being beneficial, learners must know the premises of the test clearly in advance so that the test can become part of the learning process. Knowledge of the framework of the test will strengthen the learning process associated with it. Feedback should be formed to strengthen the learner's situational and learning style awareness, and thereby reduce the probability of human failure in addition to motivate the learner (e.g., by experiencing mastery) and suggest beneficial learning strategies. Hattie (2012) writes that to make learning and teaching visible, it is essential that the teacher also acts as an evaluator who activates and manages to embed good learning strategies in the students.

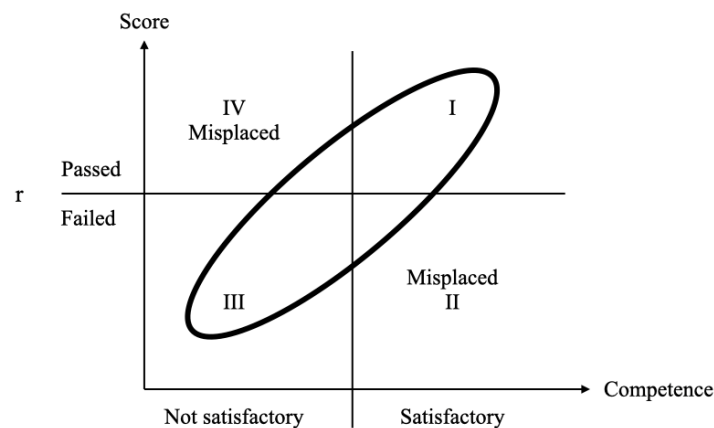
2. BACKGROUND

2.1. Introducing a Utility Function for Scoring Competence

The objective of this manuscript is to suggest a way of scoring competence and provide this as feedback to an individual learner during a learning process. Even though competence clearly is a multidimensional concept, competence is commonly measured on a scale from 0 – 100 (%), where 0 means “*Non-competent*” (or *Incompetent*) and 100 “*Fully competent*”. This attribute is typically measured by the metric “Percentage of correct answers” on a Multiple-choice test. Here, we will use the scale $[-\infty, 1]$, or a sub-set of this interval, when scoring competence.

Basically, such assessments seek to discriminate between learners who have a satisfactory competence within a specific field and those who hasn't. Thus, the goal is to discriminate between learners in what we have called group I and III in figure 1 below, and simultaneously (mis-)placing as few as possible learners into groups II or IV.

Figure 1.
Classification of learners.



All teachers (facilitators) hope learners end up in group I, having both a thorough competence of the field they are supposed to learn and being able to communicate this in an assessment by for example passing a test. Simultaneously, it's important for a teacher (and e.g., a learning institution) to identify the learners without satisfactory competence. In a good assessment, the vast majority of learners will either belong to group I or III.

Learners placed in groups II and IV are misplaced. In group IV learners have managed to discover the correct answers to enough assessment items without satisfactory competence. They typically accomplish this by guessing, or by cramming and memorizing "type problems" and procedures. To (partly) rectify this we might require a high total score for passing the assessment (indicated with a large r on figure 1).

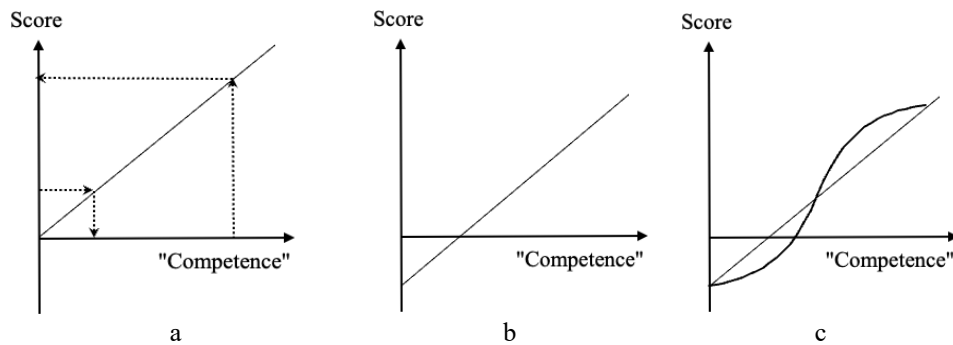
Requiring a high total score for passing an assessment will on the other hand increase the problem regarding learners in group II that have managed to acquire a satisfactory level of competence in the specified field, but still fail the test. Thus, the assessment of their accomplishment is not measured correctly and the validity with respect to measuring competence is not satisfactory. To (partly) rectify for this we might require a low total score for passing the assessment (indicated with a small r on figure 1), contrary to what was just suggested to minimize the probability of misplacing a learner into group IV.

Another concern is that learners can answer correctly through guessing, making it impossible to distinguish between correct answers based on competence versus pure luck. Without the ability to solve a particular item, learners may gain marks by guessing and thereby introduce a random factor into test scores that lowers reliability and validity.

Measuring knowledge, understanding and skills are difficult, if not impossible, in both a classroom setting and in a "real life" situation. As testing competence by automatic test procedures such as Multiple-choice tests, sometimes even presented by an AI system, has become popular it is of fundamental importance to establish good testing procedures.

As there are several issues with respect to scoring competence, we will address some characteristics such a utility (scoring) function from a set of possible outcomes of a test should possess. As mentioned above, it's common to introduce a linear utility function from the interval $[0, 100]$ to for example the interval $[0, 1]$ as illustrated on figure 2a. We will in the following argue that introducing some kind of penalty, i.e. negative scoring, if the quality of the learner's answering is "poor" as illustrated on figure 2b might be beneficial. Furthermore, we suggest that it might be beneficial to let the utility function be S-shaped as illustrated on figure 2c. This is in line with scoring as performed in Item Response theory (IRT) (Hambleton, Swaminathan, & Rogers, 1991).

*Figure 2.
a, b and c
Examples of utility functions for scoring competence.*



3. SCORING COMPETENCE

3.1. Common Techniques of Scoring Competence in Assessments

Some common techniques of scoring competence in assessments are (see figure 3);

- *Multiple-choice*, where the learner is instructed to identify the one correct statement out of k_j statements in each of J items (i.e., one correct statement ($c_j = 1$) and $k_j - c_j$ distractors for each item, $j = 1, \dots, J$). $k_j > c_j = 1$.
- *True/False*, where the learner is instructed to identify the one correct statement out of two in each of J items. (This can be analyzed as *Multiple-choice* with $k_j = 2$ and $c_j = 1$.)
- *Fill in*, where the learner is instructed to select one word out of k_j words in each of J items. (This can be analyzed as *Multiple-choice*.)
- *Multiple response*, where the learner is instructed to identify the c_j (>1) correct statements out of k_j statements in each of J items. When the learner is informed about the value of c_j , we assume $k_j > c_j > 1$ and when the learner is not informed, we assume $k_j \geq c_j \geq 1$.
- *Ordering*, where the learner is instructed to order k_j statements in each of J items ($j = 1, \dots, J$).
- *Matching pairs*, where the learner is instructed to match k_j (part)statements with k_j matching (part)statements. (This can be analyzed as *Ordering*.)

Figure 3.
Illustrations of different techniques of assessments.

	Item 1	Item 2	Item 3	Item 4
Multiple-choice	☒ v ☐ ☐ ☐	☐ ☒ v ☐ ☐	☐ ☒ v ☐ ☐	☒ v ☐ ☐ ☐
Multiple response	☒ v ☒ v ☐ ☐	☐ ☒ v ☒ v ☒ v	☒ v ☒ v ☐ ☐	☒ v ☒ v ☐ ☐
Ordering	☐ A ☐ B ☐ C ☐ D	☐ a ☐ b ☐ c ☐ d	☐ I ☐ II ☐ III ☐	☐ 1 ☐ 2 ☐ ☐

3.2. Scoring Competence in Multiple-Choice Tests

A *Multiple-choice* test is a common technique used for scoring competence based on assessments. Traditionally, multiple choice tests have been scored using a conventional *Number Right* scoring method. Correct answered items are scored with a value of 1, incorrect and omitted items with a value of zero, and the sum of the scores on the J items is the score of the assessment.

Let X_j ($j = 1, \dots, J$) be a stochastic variable characterizing the score for answering item j , and $X = \sum_{j=1}^J X_j$ the sum of scores, where

$$X_j = \begin{cases} 1 & \text{if correct} \\ 0 & \text{if incorrect.} \\ 0 & \text{if omitted} \end{cases}$$

In such a Multiple-choice test the expected value of each X_j will be positive if a learner doesn't know the correct answer and is just guessing.

$$E(X_j) = 1 \cdot \frac{1}{k_j} + 0 \cdot \frac{k_j-1}{k_j} = \frac{1}{k_j} > 0.$$

Therefore, it is expected to be beneficial for a learner to guess if she doesn't know the correct answer. And if she does, it is impossible for a teacher (facilitator) to distinguish between competence and pure luck. Various scoring methods have been presented to correct for this bias.

The *Rights Minus Wrongs* (or *Negative Marking*) scoring method penalizes the learner for incorrect responses. The fundamental idea behind this is that learners acknowledge they will lose marks for incorrect answers and become discouraged to guess. This is expected to increase test reliability and validity. If the learner decides to guess with such a scoring method, the expected score is

$$E(X_j) = 1 \cdot \frac{1}{k_j} + (-1) \cdot \frac{k_j-1}{k_j} = -\frac{k_j-2}{k_j} \leq 0.$$

The more distractors, the less the expected score becomes, and the more the learner is discouraged from guessing. But this may be too much discouraging, introducing a level of risk acceptance among the learners as a bias when assessing competence.

A favourable characteristic with a scoring method may be that the expected score is zero if a learner is guessing. For this to happen when the reward for getting the question correct is 1, the penalty for an incorrect answer must be $-1/(k_j-1)$. That is,

$$X_j = \begin{cases} 1 & \text{if correct} \\ \frac{-1}{k_j-1} & \text{if incorrect.} \\ 0 & \text{if omitted} \end{cases}$$

Now, in a Multiple-choice test with k_j alternatives the expected score on each item is

$$E(X_j) = 1 \cdot \frac{1}{k_j} + \left(-\frac{1}{k_j-1}\right) \cdot \frac{k_j-1}{k_j} = 0.$$

This kind of neutrality with respect to guessing may be beneficial because of the not too strict discouragement to guess.

3.3. Partial Knowledge in Multiple-Choice Tests

Learners may be able to determine that some of the statements are incorrect even though they cannot identify the correct one, though. Being able to eliminate some such distractors is reflecting what is called "*partial competence*" and "*partial knowledge*".

If a learner eliminates *one* distractor correctly in a Multiple-choice test, the expected score is

$$E(X_j) = 1 \cdot \frac{1}{k_j-1} + \left(-\frac{1}{k_j-1}\right) \cdot \frac{k_j-2}{k_j-1} = \frac{1}{(k_j-1)(k_j-1)}.$$

If the learner eliminates *two* distractors correctly, the expected score is

$$E(X_j) = 1 \cdot \frac{1}{k_j-2} + \left(-\frac{1}{k_j-1}\right) \cdot \frac{k_j-3}{k_j-2} = \frac{2}{(k_j-1)(k_j-2)}.$$

And so on.

Table 1.
Expected scores after correctly elimination of distractors.

E(X _j)		Correctly eliminated distractors				
		0	1	2	3	4
Number of alternatives, k _j	2	0	1			
	3	0	.25	1		
	4	0	.11	.33	1	
	5	0	.06	.17	.38	1
	6	0	.04	.10	.20	.40

Table 1 illustrates that with the scoring method mentioned above, the effect of guessing is neutral, as a learner who is not able to identify any distractors (i.e., an incompetent learner) will have an expected score equal to 0. If a learner manages to correctly eliminate some distractors, though, guessing will have a positive expected effect. To avoid this positive effect by guessing, it is possible that an effective penalty that discourages guessing should exceed the standard penalty of $-1/(k_j - 1)$, but by implementing such negative marking, this will reflect the learners' answering strategies and risk-taking behaviour instead of actual competence. In fact, we see it as beneficial that for a learner able to eliminate some distractors (i.e., a learner with partial knowledge), the expected score is positive.

In line with this, we define a learner

- to have *full knowledge* if $E(X_j) = 1$
- to have *partial knowledge* if $0 < E(X_j) < 1$
- to be *incompetent (non-competent)* if $E(X_j) \leq 0$.

A variety of different partial-credit scoring methods are presented in the literature (Bush, 2001, Frary, 1989, Kurz, 1999, Traub et al., 1969)

3.4. Desirable Characteristics

Based on this discussion for the Multiple-choice technique, we suggest the following preliminary characteristics of a favorable scoring method. Let X_j = Score on item j, and

1. Completely correct $\Rightarrow X_j = 1$
2. Result as good as expected when guessing $\Rightarrow X_j = 0$
3. Result worse than expected when guessing $\Rightarrow X_j < 0$
4. Neutrality with respect to guessing $\Rightarrow E(X_j) = 0$
5. Partial knowledge is rewarded $\Rightarrow E(X_j | \text{Partial knowledge}) > 0$

We will in the following chapters discuss what these requirements implies with different scoring techniques and expand the list to identify the score to reward partly correctly answered items (indicating partial knowledge).

4. SCORING COMPETENCE IN MULTIPLE RESPONSE TESTS

4.1. Scoring Competence in Multiple Response Tests with Known c_j

4.1.1. Rewarding Only Completely Correct Responses

Let the learner be instructed to identify the c_j ($1 < c_j < k_j$) correct statements out of k_j statements in each of J items. Let the sum of the scores on the items be the score of the assessment, $X = \sum_{j=1}^J X_j$. Assume completely correct items will be scored with a value of 1, and incorrect and omitted answers with a value of zero. That is,

$$X_j = \begin{cases} 1 & \text{if completely correct} \\ 0 & \text{if not completely correct} \\ 0 & \text{if omitted} \end{cases}$$

In such a multiple response test the expected value of each score will be positive if a learner is informed about the number of correct statements, is suggesting c_j statements as correct, but doesn't know which statements are correct, and is guessing.

$$E(X_j) = 1 \cdot \frac{1}{\binom{k_j}{c_j}} + 0 \cdot \frac{\binom{k_j}{c_j} - 1}{\binom{k_j}{c_j}} = \frac{1}{\binom{k_j}{c_j}} > 0.$$

Introducing the discouraging factor $-\frac{1}{\binom{k_j}{c_j} - 1}$ as a penalty for a not completely correct answer, then

$$X_j = \begin{cases} 1 & \text{if completely correct} \\ -\frac{1}{\binom{k_j}{c_j} - 1} & \text{if not completely correct} \\ 0 & \text{if omitted} \end{cases}$$

and

$$E(X_j) = 1 \cdot \frac{1}{\binom{k_j}{c_j}} + \left(-\frac{1}{\binom{k_j}{c_j} - 1} \right) \cdot \frac{\binom{k_j}{c_j} - 1}{\binom{k_j}{c_j}} = 0.$$

With a given number of correct alternatives (c_j) the discouraging factor is decreasing with increasing number of statements (k_j). This seems "fair" as the item then becomes more difficult to answer completely correct when guessing. The effect of guessing is neutral, but if a learner manages to correctly identify some statements (either as correct or as incorrect) before guessing, guessing will have a positive expected effect reflecting "*partial knowledge*".

4.1.2. Rewarding Partial Knowledge

It seems reasonable also to reward a learner for answering partial correct on an item. If the scoring rule only is taking into account the number of correctly identified correct statements, though, the optimal strategy for the learner would be always to suggest that all k_j statements are correct. Instead, let's introduce,

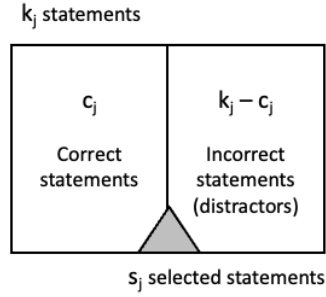
$$X_j = \frac{Y_j}{k_j} = \frac{\text{\#correctly identified correct statements} + \text{\#correctly identified incorrect statements}}{k_j}.$$

It seems too spendable to reward a learner for managing to identify less than the expected correctly identified statements if she is just guessing. Therefore, we suggest the scoring

- let $X_j = Y_j/k_j$ when $Y_j > E(Y_j)$
- let $X_j = 0$ when $Y_j = E(Y_j)$
- introduce a penalty such that the overall expected value of the score will be neutral, i.e. $E(X_j) = 0$, when $Y_j < E(Y_j)$
- let $X_j = 0$ if omitted.

Observe that given the learner is guessing and is proposing $s_j = c_j$ statements as correct, the number of correctly identified correct statements, V_j , will follow a Hypergeometric probability distribution, $V_j \sim \text{Hyp}(k_j, c_j, s_j)$.

Figure 4.
Illustration of a Hypergeometric experiment.



Example

Let $k_j = 5$ statements of which $c_j = 3$ are correct, $k_j - c_j = 5 - 3 = 2$ are distractors, and the learner is suggesting $s_j = c_j = 3$ statements as correct. (See figure 4.) The number of correctly identified correct statements, V_j , will follow a Hypergeometric probability distribution $\text{Hyp}(k_j=5, c_j=3, s_j=c_j=3)$ and

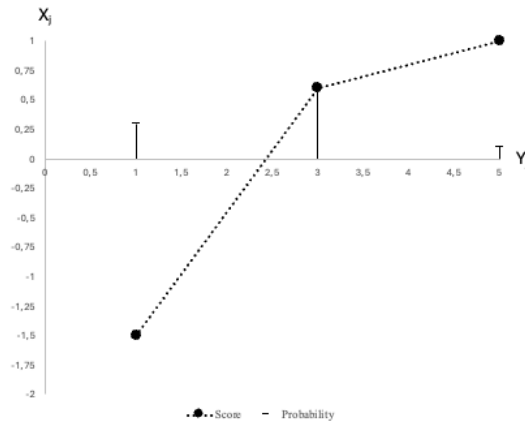
$$V_j = 1 \Leftrightarrow Y_j = 1 \text{ and } P(Y_j = 1) = P(V_j = 1) = 0.3$$

$$V_j = 2 \Leftrightarrow Y_j = 3 \text{ and } P(Y_j = 3) = P(V_j = 2) = 0.6$$

$$V_j = 3 \Leftrightarrow Y_j = 5 \text{ and } P(Y_j = 5) = P(V_j = 3) = 0.1$$

If a learner is guessing, the expected number of correctly identified statements (both correct and incorrect) will be $E(Y_j) = 2.6$. Therefore, as the outcomes $Y_j = 3$ and $Y_j = 5$ are better than the expected value when guessing they are given scores $3/5$ and $5/5 = 1$, respectively. Only the outcome $Y_j = 1$ is worse than the expected value when guessing and to ensure a neutrality with respect to guessing the penalty for $Y_j = 1$ will be (approx.) -1.5 .

Figure 5.
Scoring based on Y_j .



Observe that a "good" strategy for an incompetent learner, instead of guessing, in this situation would be suggesting that all statements are correct. As $Y_j = 3 > E(Y_j) = 2.6$, this would give a score $3/5$. With multiple response tests we therefore suggest letting the number

of correct statements be the result of a stochastic experiment and unknown to the learner, in any case when the relative number of correct statements is "large".

Example

Let there be $k_j = 6$ statements of which $c_j = 3$ are correct, $k_j - c_j = 6 - 3 = 3$ are distractors, and the learner is suggesting $s_j = c_j = 3$ statements as correct. (See figure 4.)

The number of correctly identified correct statements, V_j , will follow a Hypergeometric probability distribution $\text{Hyp}(k_j=6, c_j=3, s_j=c_j=3)$ and

$$V_j = 0 \Leftrightarrow Y_j = 0 \text{ and } P(Y_j = 0) = P(V_j = 0) = 0.05$$

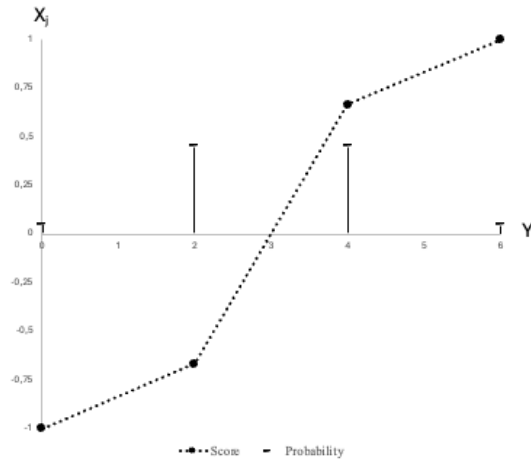
$$V_j = 1 \Leftrightarrow Y_j = 2 \text{ and } P(Y_j = 2) = P(V_j = 1) = 0.45$$

$$V_j = 2 \Leftrightarrow Y_j = 4 \text{ and } P(Y_j = 4) = P(V_j = 2) = 0.45$$

$$V_j = 3 \Leftrightarrow Y_j = 6 \text{ and } P(Y_j = 6) = P(V_j = 3) = 0.05$$

If a learner is guessing, the expected number of correctly identified statements (both correct and incorrect) will be $E(Y_j) = 3$. Therefore, as the outcomes $Y_j = 4$ and $Y_j = 6$ are better than the expected value when guessing they are given scores $4/6$ and $6/6=1$, respectively. The outcomes $Y_j = 0$ and $Y_j = 2$ is worse than the expected value when guessing. To ensure a neutrality with respect to guessing there is an infinite number of possible values for the penalties. We suggest setting the penalties to ensure the kind of symmetry suggested in figure 2c. For $Y_j = 0$ we suggest the score $X_j = -1$, and for $Y_j = 2$ we suggest the score $X_j = -2/3$.

Figure 6.
Scoring based on Y_j .



4.2. Scoring Competence in Multiple Response Tests with Unknown C_j

4.2.1. Rewarding Partial Knowledge

Let the learner be instructed to identify the C_j correct statements out of k_j statements in each of J items. Let the sum of the scores on the items be the score of the assessment, $X = \sum_{j=1}^J X_j$. Assume the test designer is deciding to include the number of correct statements, $C_j = c_j$, according to a discrete probability distribution, and that the positions of these c_j correct statements are randomly selected among the k_j positions.

We recommend utilizing random generators both when deciding how many correct statements (c_j out of k_j) should be presented to the learner, and in which order the different statements should be presented. If not, it's easy presenting correct statements first and the distractors later. (It is when the test designer must be creative and invent the distractors that more thinking is required, thus making it tempting to postpone this task.) Our experience is that learners are quick to identify any such bias (even when it's not present!), which will affect the validity of the test. Furthermore, it is good pedagogy to minimize the number of distractors.

Example

Assume

- k_j = Total number of statements = 5
- $C_j = c_j = 3$ The number of correct statements as an outcome of a discrete probability distribution (for example a uniform $U[1, 2, 3, 4, 5]$)
- $S_j = s_j$ The number of suggested correct statements by the learner, $S_j \sim U[0, 1, 2, 3, 4, 5]$
- C_j and S_j are independent stochastic variables
- V_j = The number of correctly identified correct statements
- Y_j = The sum of the number of correctly identified correct statements and the number of correctly identified incorrect statement.

Then the possible outcomes on item j will be as presented in table 2.

Table 2.
Possible outcomes on an item.

S_j	0	1	2	3	4	5
V_j	0	0, 1	0, 1, 2	1, 2, 3	2, 3	3
Y_j	2	1, 3	0, 2, 4	1, 3, 5	2, 4	3

As

$$P(Y_j = y_j) = \sum_l P(S_j = s_l, V_j = v_l) = \sum_l P(S_j = s_l) P(V_j = v_l | S_j = s_l)$$

we see from table 2 and utilizing that $V_j | S_j$ is Hypergeometric distributed that

$$\begin{aligned} P(Y_j = 4) &= P(S_j = 2) P(V_j = 2 | S_j = 2) + P(S_j = 4) P(V_j = 3 | S_j = 4) \\ &= 1/6 \cdot 0.3 + 1/6 \cdot 0.4 \approx 0.12 \end{aligned}$$

The probability distribution of Y_j will be (approx.) as presented in table 3.

Table 3.
The probability distribution of Y_j .

y_j	0	1	2	3	4	5
$P(Y_j = y_j)$	0.02	0.12	0.37	0.37	0.12	0.02

As the expected value of Y_j , $E(Y_j) = 2.5$, we suggest scoring the larger than expected values according to the same principle as suggested earlier (see chapter 3.1.2). That is,

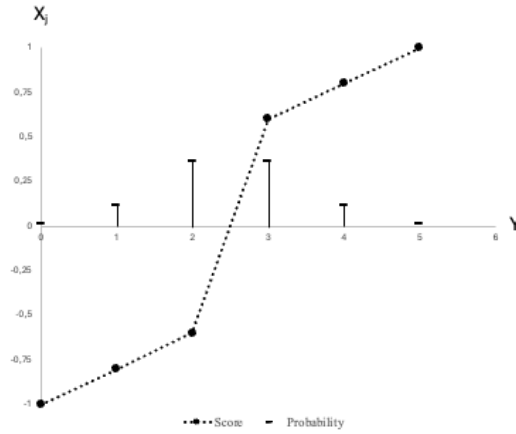
$$Y_j = 3 \Rightarrow X_j = 3/5$$

$$Y_j = 4 \Rightarrow X_j = 4/5$$

$$Y_j = 5 \Rightarrow X_j = 5/5 = 1$$

To ensure the neutrality with respect to guessing there is an infinite number of possible values for the penalties. Again, we suggest setting the penalties to ensure the kind of symmetry suggested in figure 2c. For $Y_j = 0$ we suggest the penalty $X_j = -1$, for $Y_j = 1$ we suggest $X_j = -4/5$, and for $Y_j = 2$ we suggest $X_j = -3/5$.

Figure 7.
Scoring based on Y_j .



This procedure is also rewarding partial competence.

5. SCORING COMPETENCE IN ORDERING TESTS

5.1. Rewarding Only Completely Correct Responses

Let the learner be instructed to order k_j statements in J items in a specific order. This has a parallel to the famous "*matching hats problem*" within combinatorics originally described by Montmort in 1713 (Hathout, 2003). When scoring such an ordering test with k_j elements, a scoring procedure with penalty that effectively discourages guessing, and keeps a neutrality with respect to guessing, may be defined by

$$X_j = \begin{cases} 1 & \text{if completely correct} \\ -\frac{1}{k_j!-1} & \text{if not completely correct.} \\ 0 & \text{if omitted} \end{cases}$$

The neutrality is established as the expected score on each item is

$$E(X_j) = 1 \cdot \frac{1}{k_j!} + \left(-\frac{1}{k_j!-1}\right) \cdot \frac{k_j!-1}{k_j!} = 0.$$

With this scoring method, the effect of guessing is neutral, but if a learner manages to correctly eliminate some alternatives guessing will again give a positive expected effect. This is suggesting that with some partial knowledge it will be beneficial to guess.

5.2. Matching Hats Problem

5.2.1. Matching Hats Problem. Part 1

A group of k men enter a restaurant and check their hats. The hat-checker is absent minded and upon leaving she redistributes the hats back to the men at random.

Introduce Z_i = The i -th man leaves with his own hat ($i = 1, 2, \dots, k$). Then,

$$P(\text{Man } i \text{ leaves with his own hat}) = P(Z_i) = \frac{(k-1)!}{k!} = \frac{1}{k}$$

Similarly,

$$P(\text{Man } i \text{ and } j \text{ leaves with their own hats}) = P(Z_i \cap Z_j) = \frac{(k-2)!}{k!}$$

$$P(\text{Man } i, j \text{ and } l \text{ leaves with their own hats}) = P(Z_i \cap Z_j \cap Z_l) = \frac{(k-3)!}{k!}$$

and so on. Now,

$$\begin{aligned} P(\text{At least one man leaves with his own hat}) &= P(\cup_{i=1}^k Z_i) \\ &= \sum_{i=1}^k P(Z_i) - \sum_{i < j} P(Z_i \cap Z_j) + \dots + (-1)^{k+1} P(Z_1 \cap \dots \cap Z_k) \\ &= \binom{k}{1} \frac{(k-1)!}{k!} - \binom{k}{2} \frac{(k-2)!}{k!} + \binom{k}{3} \frac{(k-3)!}{k!} + \dots + (-1)^{k+1} \binom{k}{k} \frac{(k-k)!}{k!} \\ &= \frac{1}{1!} - \frac{1}{2!} + \frac{1}{3!} \dots + (-1)^{k+1} \frac{1}{k!} \end{aligned}$$

Furthermore,

$$\begin{aligned} P(\text{No man leaves with his own hat}) &= 1 - P(\text{At least one man leaves with his own hat}) \\ &= 1 - \left[\frac{1}{1!} - \frac{1}{2!} + \frac{1}{3!} \dots + (-1)^{k+1} \frac{1}{k!} \right] \\ &= \frac{D(k)}{k!} \end{aligned}$$

where $D(k)$ is the number of *derangements* of the k items (i.e., a permutation of the elements of a set in which no element appears in its original position). Consequently,

$$D(k) = k! \left\{ 1 - \left[\frac{1}{1!} - \frac{1}{2!} + \frac{1}{3!} \dots + (-1)^{k+1} \frac{1}{k!} \right] \right\}$$

Introduce

$$Y = \# \text{ correctly returned hats (out of } k).$$

Then,

$$P(\text{Exactly } y \text{ correctly returned hats out of } k) = P(Y = y) = \frac{D(k-y)}{y! (k-y)!}$$

5.2.2. Matching Hats Problem. Part 2

Observe that

$$D(1) = 0$$

$$D(2) = 1$$

$$D(k) = (k-1)\{D(k-1) + D(k-2)\}$$

introduces an alternative, and maybe more convenient, way of calculating $D(k)$.

5.2.3. Matching Hats Problem. Part 3

Observe that

$$E(Y) = \sum_{y=0}^k y P(Y = y) = 1.$$

That is, *we always expect exactly one match*, regardless of how many men are present.

This can be deduced as follows. Let

$$Y = Z_1 + Z_2 + \dots + Z_k$$

where Z_i is 1 if the i -th man gets his own hat back, and 0 otherwise. Since

$$E(Y) = E(Z_1) + E(Z_2) + \dots + E(Z_k),$$

and

$$E(Z_i) = 0 \cdot P(Z_i = 0) + 1 \cdot P(Z_i = 1) = P(Z_i = 1) = 1/k \text{ for } i = 1, 2, 3, \dots, k$$

it follows that

$$E(Y) = 1/k + 1/k + \dots + 1/k = 1.$$

Thus, no matter how many men are involved, we expect that exactly one man receives his own hat.

5.3. Rewarding Partial Knowledge

Let

$Y_j = \#$ correctly placed statements (out of k_j) in item j ($j = 1, \dots, J$).

Then, the probability distribution of Y_j is (see subchapter 4.2.1)

$$P(Y_j = y) = \frac{\sum_{i=0}^{k_j-y} \frac{(-1)^i}{i!}}{y!}; y = 0, 1, \dots, k_j$$

Table 4.
The probability distribution of Y_j for selected values of k_j .

P(y)	k_j						
y	2	3	4	5	6	7	8
0	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{3}{8}$	$\frac{11}{30}$	$\frac{53}{144}$	$\frac{309}{840}$	$\frac{2119}{5760}$
1		$\frac{1}{2}$	$\frac{1}{3}$	$\frac{3}{8}$	$\frac{11}{30}$	$\frac{53}{144}$	$\frac{103}{280}$
2	$\frac{1}{2}$		$\frac{1}{4}$	$\frac{1}{6}$	$\frac{3}{16}$	$\frac{11}{60}$	$\frac{53}{288}$
3		$\frac{1}{6}$		$\frac{1}{12}$	$\frac{1}{18}$	$\frac{1}{16}$	$\frac{11}{180}$
4			$\frac{1}{24}$		$\frac{1}{48}$	$\frac{1}{72}$	$\frac{1}{64}$
5				$\frac{1}{120}$		$\frac{1}{240}$	$\frac{1}{360}$ = .003
6					$\frac{1}{720}$		$\frac{1}{1440}$
7						$\frac{1}{5040}$	
8							$\frac{1}{40320}$

Remember that $E(Y_j) = 1$, independent of the value of k_j . That is, when a learner is guessing, we're always expecting exactly one correctly placed statement. Therefore, we feel a fair score for exactly one correctly placed statement should be 0. (See row 2 in table 5 below.) We suggest a score of 1 for all statements placed in the correct order.

That is, the score for $Y_j = 1$ and $Y_j = k_j$ are given, and we need to decide on the scores for the values $y = 0, 2, 3, \dots, k_j - 2$. (Remember $y = k_j - 1$ is impossible.) We find it reasonable to suggest,

$$\text{score for exactly } y_j \text{ correctly placed statements out of } k_j, X_j = \frac{y_j}{k_j}$$

for $y_j > 1$ and $k_j > 4$. (For the special cases of $k_j = 2, 3, 4$, see our suggestions in table 5.)

Furthermore, we suggest introducing a penalty for no correctly placed statements (i.e., a result worse than what is expected when guessing), such that the expected score will become 0. Then, for some selected values of k_j , the scoring will be as presented in table 5 below.

Table 5.
Suggested scoring resulting in neutrality when guessing.

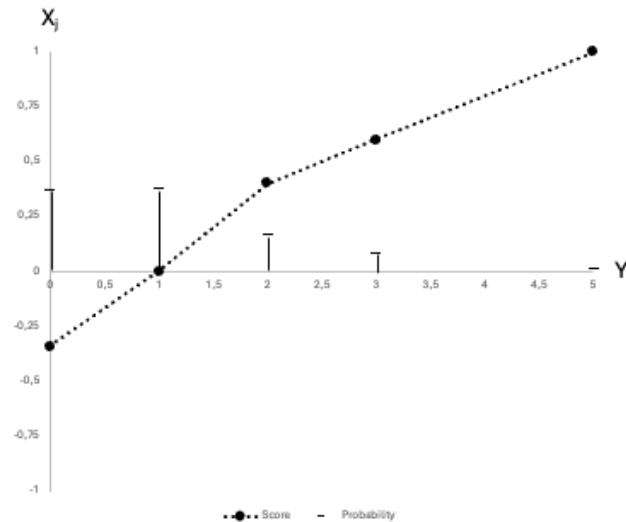
Score	k_j						
y_j	2	3	4	5	6	7	8
0	-1	$-\frac{1}{2}$	$-\frac{4}{9}$	$-\frac{15}{44}$	$-\frac{228}{795}$	$-\frac{9555}{38934}$	$-\frac{3186}{14833}$
1		0	0	0	0	0	0
2	1		$\frac{1}{2}$	$\frac{2}{5}$	$\frac{2}{6}$	$\frac{2}{7}$	$\frac{2}{8}$
3		1		$\frac{3}{5}$	$\frac{3}{6}$	$\frac{3}{7}$	$\frac{3}{8}$
4			1		$\frac{4}{6}$	$\frac{4}{7}$	$\frac{4}{8}$
5				1		$\frac{5}{7}$	$\frac{5}{8}$
6					1		$\frac{6}{8}$
7						1	
8							1

We see that the penalty for having no correctly placed statements is reduced with increasing difficulty (i.e., with increasing number of alternatives). The effect of guessing is neutral, but if a learner manages to correctly eliminate some alternatives before guessing, guessing will have a positive expected effect reflecting “*partial knowledge*”.

Example

Let $k_j = 5$. With data from table 5, the scoring may be illustrated as in figure 8.

Figure 8.
Scoring based on Y_j .



6. CONCLUSION

Based on the discussion above, we suggest using either Multiple-choice tests with a random number of correct alternatives, where the number is not communicated to the learner, or some kind of ordering test to estimate a learner's competence. We suggest giving the score 1 for a completely correct answer, a positive score (depending on the test) for partial correct answers better than expected if the learner is guessing, 0 for a result exactly as expected if guessing, and introducing penalties for answers not as good as expected if guessing. The size of the penalty should ensure that the expected score, when guessing, is 0. All suggested techniques of scoring are taking into account partial knowledge.

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Chapter # 2

INITIAL TEACHER EDUCATION: TEACHING OBSERVATION ORAL FEEDBACK PRACTICES IN THE UNITED ARAB EMIRATES

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ABSTRACT

School-based practice is widely recognised as a cornerstone of effective initial teacher education programmes, with mentor feedback playing a crucial role in student-teacher development. This action research study focuses on post-teaching observation feedback (PTOF), the discussions between mentors and mentees following observed teaching sessions. Conducted at an initial teacher education institution for Emirati women in the United Arab Emirates, the study examines and enhances PTOF practices from the perspectives of Emirati and expatriate college mentors, as well as Emirati student-teachers. Cycle 1 gathered insights through qualitative questionnaires and focus group interviews, informing a series of professional development sessions that produced new practice guidelines. Cycle 2 assessed the impact of these interventions, with data collected through interviews and focus groups. Thematic analysis was used to evaluate data from both cycles. Findings from Cycle 1 revealed significant inconsistencies in PTOF practices, while Cycle 2 indicated improved structure and consistency. To further enhance PTOF, the study recommends allocating more time and providing contextual developmental support.

Keywords: initial teacher education, teaching observation feedback, mentoring, reflective practice, Emirati student-teachers.

1. INTRODUCTION

Learning through practice has long been recognised as a fundamental component of effective initial teacher education (ITE) programmes (Allen, Singh, & Rowan, 2019). Darling-Hammond et al. (2017) emphasise that mentor feedback during school-based practice (SBP) is essential for student-teachers to develop into competent and well-prepared educators. This study focuses on mentor feedback, specifically the oral feedback provided by mentors after observing student-teachers during SBP. This interaction, referred to as post-teaching observation feedback (PTOF), involves mentors meeting with mentees to discuss their recently observed teaching.

Bjørndal (2020) identifies PTOF as a critical element in fostering student-teacher development, asserting that effective feedback must be collaborative, critical, and reflective. Similarly, Clarke, Triggs, and Nielsen (2014) highlight PTOF as a central responsibility of mentors. However, a notable limitation in the existing literature is its predominantly Western-centric perspective. To address this gap, this research investigates whether findings from Western PTOF literature are applicable within the context of ITE in the United Arab Emirates (UAE).

This study examines professional and programme development, evaluates a shift towards collaborative approaches, and provides participants with a platform to voice their perspectives. Using an action research (AR) methodology, the study comprises two cycles.

The first cycle explores the perspectives of expatriate and Emirati college mentors and female Emirati student-teachers regarding PTOF practices at a federal ITE institution. Insights from Cycle 1 informed the design of professional development (PD) sessions, during which new practice guidelines were developed. Cycle 2 evaluates the effectiveness of these PD sessions and the subsequent implementation of the revised practice guidelines, drawing on participant feedback.

2. BACKGROUND

This action research study was conducted within the ITE department of a female higher education (HE) institution in the UAE. This institution, the largest HE provider in the country, operates 16 gender-segregated campuses across the UAE. The ITE programme, offered on five female campuses across four emirates, is an eight-semester (four-year) undergraduate bachelor's degree. The research setting is one of these campuses, where 12 education faculty members are evenly split between Emirati and expatriate staff. The expatriate faculty originate from five countries spanning four continents, with three of the 12 faculty members being male. While most students join the education programme directly from secondary school, a small proportion are mature students.

The institution is currently accredited to offer a bachelor's degree in early childhood education, which qualifies graduates to teach in kindergartens and up to grade 2 in UAE public schools. Student-teachers undertake both core and general education courses alongside a School-Based Practice (SBP) course each semester. These courses are designed to integrate practice and theory to support student-teachers during their SBP experiences.

During SBP, college mentors—typically education faculty—observe student-teachers and provide PTOF. Additionally, school-based mentors, usually the classroom teachers, observe student-teachers during their teaching sessions. Over the course of the programme, student-teachers spend between 10 and 40 days per semester in schools, with the duration increasing incrementally. By the end of the programme, each student-teacher completes a total of 155 days of school-based practice.

3. LITERATURE REVIEW

The critical components of PTOF explored in this study—reflective practice, mentoring, and feedback—are integral to teacher education. Each plays a pivotal role in bridging theory and practice for student-teachers and shaping their professional development.

3.1. Reflective Practice

Reflective practice is a cornerstone of the initial teacher education (ITE) model at this institution, enabling student-teachers to connect theory and practice during school-based placements (SBP). It fosters their ability to develop pedagogical skills while constructing a reflective understanding of teaching. Gadsby (2022) situates reflective practice at the heart of teacher development. Bjørndal (2020) concurs, noting that reflection enhances PTOF by enabling mentors to guide student-teachers in cultivating dispositions, knowledge, and skills.

Building on Dewey's (1933) belief that reflection arises from doubt and problem-solving, Schön (1983; 1987) introduced the concept of "professional artistry," wherein reflective practitioners integrate intuition and experiential knowledge to manage complex teaching situations. Schön emphasises two key forms of reflection: reflection in action (during the event) and reflection on action (post-event). These processes enable

student-teachers to draw on tacit knowledge, learn from experience, and achieve greater expertise.

While reflection is critical, its implementation in ITE often lacks structure. Ward and McCotter (2004) highlight that reflective practice is embedded rather than explicitly taught in ITE curricula. Yet, deliberate instruction is essential, as reflection is not intuitive (Williams & Grudnoff, 2011; Farrell, 2019). Mulryan-Kyne (2021) advocates for stronger emphasis on reflection in coursework, while Dyer and Taylor (2012) underscore the importance of mentorship in fostering reflective skills. However, Russell (2013) cautions that poorly defined reflective practices by mentors may hinder student-teacher development, suggesting the need for improved mentor training. Reflection evolves in sophistication, progressing from technical to critical, iterative thinking (Slade, Burnham, Catalana, & Waters, 2019; Dervent, 2015). This underscores the necessity of repeated opportunities for reflection throughout ITE.

3.2. Mentoring

Mentoring plays a central role in supporting student-teachers during PTOF. Ellis, Alonzo, and Nguyen (2020) propose that mentoring should be reciprocal, involving dialogue and co-construction of knowledge. However, Mena, Hennissen, and Loughran (2017) observe that traditional, directive mentoring models persist in many ITE contexts.

Effective mentoring hinges on adequate mentor preparation. Studies (e.g., Nguyen, 2017; Wexler, 2019) reveal that insufficient mentor training undermines the quality of mentoring. Orland-Barak (2016) emphasises the need for mentors to be equipped with skills to support and challenge mentees. Izadinia (2017) criticises the lack of structured mentor development programmes in many ITE institutions. Mackie (2020) argues for consistent mentor education to address the complexity of mentoring, highlighting that teaching expertise alone does not guarantee effective mentorship (Coe, Aloisi, Higgins, & Major, 2014). Without professional development, mentors often default to hierarchical approaches based on their personal experiences (Jones, Tones, Foulkes, & Jones, 2022).

The mentor-mentee relationship is pivotal to the success of SBP (Ellis & Osborne, 2015). Effective relationships are built on respect and collaboration, though time constraints during short placements can hinder this process (Wilson & Huynh, 2020). Empathy, support, and open communication are essential mentor attributes (Sheridan & Young, 2017; Yuan & Lee, 2016). Collaborative models, as proposed by Clutterbuck (2004), promote reciprocal partnerships and empower mentees to set agendas and develop their teaching philosophies. However, traditional models with power imbalances can lead to vulnerability and hinder professional growth (Mackie, 2020).

3.3. Feedback

Mentor feedback is a critical component of PTOF, bridging theory and practice (Akkuzu, 2014). Despite its importance, research on PTOF, particularly in the Middle East, remains limited (Rehman & Al-Bargi, 2014; Ibrahim, 2013). Western contexts dominate the discourse, suggesting a need for localised studies to inform practice.

Evaluative feedback, such as grading lesson observations, is contentious. While it may motivate some student-teachers (Entwistle & McCune, 2004; Hojeij, Atallah, Baroudi, & Tamim, 2021), it often fosters ambiguity and power imbalances in the mentor-mentee relationship (Jones, Tones, Foulkes, & Jones, 2021). Conversely, dialogical feedback emphasises collaboration and enquiry, aligning with this institution's reflective ITE model (Ellis et al., 2020; Ambrosetti, Knight, & Dekkers, 2014). Grimmett, Forgasz, and White (2018) highlight the transformative potential of dialogic practices, which enable mentees to critically examine their teaching and adopt new approaches.

3.4. Conclusion

Reflective practice, mentoring, and feedback are interconnected elements of PTOF that significantly influence student-teacher development. While existing literature provides valuable insights, there are gaps in localised research and inconsistencies in practice, particularly in mentor training and the application of reflective models. Addressing these challenges requires a more structured approach to mentor development and a greater emphasis on dialogical feedback to align with the reflective ethos of this institution's ITE programme.

4. RESEARCH QUESTIONS

This study addresses six investigatory research questions. The first three explore participants' pre-intervention perspectives on PTOF and inform the subsequent interventions. The latter three evaluate the impact of these interventions and their implementation, as perceived by the participants.

The Exploratory Cycle: Cycle 1

- **Research Question 1:** How do college mentors and student-teachers describe their current experiences of giving and receiving PTOF?
- **Research Question 2:** How do college mentors and student-teachers describe their theoretical approach to, and/or practice of, mentoring and giving or receiving PTOF?
- **Research Question 3:** What suggestions, if any, do college mentors and student-teachers have for improving PTOF?

The Evaluation Cycle: Cycle 2

- **Research Question 4:** How do college mentors and student-teachers describe their post-intervention experiences of PTOF?
- **Research Question 5:** In what ways, if at all, do college mentors and student-teachers perceive that the interventions have altered their theoretical approach to, and/or practice of, mentoring and giving or receiving PTOF?
- **Research Question 6:** What suggestions, if any, do college mentors and student-teachers have for further developing PTOF practices?

5. THE ACTION RESEARCH MODEL

This study adopts the action research (AR) model proposed by Coghlan and Brannick (2014), which is designed to facilitate organisational change. The model begins with a context and purpose stage, followed by four iterative phases of the AR cycle. The approach is well-suited to the study's aim of enhancing mentoring practices within an educational institution.

6. DATA COLLECTION

6.1. Cycle 1

Eighteen student-teachers (six in each group) participated in three-year level focus group interviews, with six participants in each group. The interview protocol consisted of two main questions and eight supplementary questions, with potential follow-up prompts. Recognising that the participants spoke English as a second or additional language, the questions were designed to be concise, clear, and accessible, using familiar terminology. This approach aimed to maximise opportunities for participants to express their views.

Additionally, eight college mentors completed an anonymous online qualitative questionnaire comprising 21 questions: three closed and 18 open-ended. The closed questions were designed to be straightforward, while the open-ended ones elicited richer responses, as recommended by Cohen, Manion, and Morrison (2011).

6.2. Cycle 2

In Cycle 2, 18 student-teachers (six in each group) participated in three-year level focus group interviews, this time with five questions and six potential follow-up prompts. Six college mentors engaged in one-to-one interviews consisting of six open-ended questions and prompts. Following Jacob and Furgerson's (2012) recommendation, initial questions were designed to be familiar and easy to answer before progressing to more in-depth queries, allowing for richer, reflective responses (Whiting, 2008).

All data were collected online due to COVID-19 pandemic restrictions and mandated social distancing protocols.

7. DATA ANALYSIS

Thematic analysis (TA), as outlined by Braun and Clarke (2006, 2013), was employed to examine the data. This reflexive six-stage approach enabled the development of a rich, detailed, and nuanced account of participants' perspectives. The process was iterative rather than linear, involving constant movement between data, codes, clusters, and themes.

7.1. Cycle 1 Findings

The first cycle of this AR study's findings revealed that most participants described their experience of PTOF as confusing. College mentors were uncertain of their roles and responsibilities. Student-teachers were unclear what college mentors expected from them, perceiving each college mentor to have different expectations. At the time, there were no institutional guidelines, policies, or procedures for PTOF practice. Although this institution's SBP handbook outlined college mentor roles and responsibilities, these were poorly defined, unspecific and not directly related to PTOF. Cycle 1 found consensus on beginning PTOF positively then moving onto developmental feedback; however, there was less consistency to ending PTOF, to conducting meetings before SBP, and to requesting student-teachers complete pre-PTOF self-reflections. Most participants explained that there was not enough time to give and receive PTOF. College mentors considered their SBP workload too heavy, and student-teachers recognised that PTOF was often rushed. College mentors equated longer PTOF with quality feedback and student-teachers explained they needed time during PTOF to feel comfortable enough to discuss their practice openly. Time required to build relationships was perceived as important, particularly as student-teachers preferred to be paired with a college mentor who had taught them before. Additionally, college mentors

explained that they spent time supporting school-based mentors. All the college mentors provided examples of how they were positive, sensitive and tried to instil confidence in student-teachers during PTOF. While the student-teachers mostly recognised that college mentors tried to encourage and support them, they explained that they wanted college mentors to be considerate when they gave feedback. If college mentor language was negative, they felt it was detrimental to their development. A few student-teachers explained that on occasion they received contradictory positive oral PTOF and what they perceived as negative written PTOF. It was unclear whether student-teachers misinterpreted oral PTOF or college mentors withheld less positive oral feedback.

Opinion was divided when college mentors described their theoretical approach to mentoring and PTOF. Half the college mentors said that they mostly implemented directive approaches, while the remaining half indicated that they mostly implemented either a collaborative or a combination of directive and collaborative approaches. The student-teachers perceived that they mostly received and indeed wanted directive approaches to mentoring and PTOF. It appeared that college mentors implemented their preferred approach as and when they chose, rather than when it was developmentally appropriate for student-teachers. This inconsistent implementation likely accounted for student-teachers' perceptions of differing levels of mentoring and PTOF support.

The directive approach to mentoring and PTOF appeared to be influenced by the requirement to grade each observed lesson. Again, opinion was divided. Half the college mentors felt that grading individual lessons and discussing grades during PTOF motivated student-teachers and supported their development. The other half considered grading all formative lesson observations as not conducive to student-teacher learning. Interestingly, most student-teachers explained that they found grading individual lessons unmotivating and a distraction from the developmental feedback the college mentors gave. Although half the college mentors indicated that they implemented collaborative approaches to mentoring and PTOF, there was limited evidence of developmental feedback that was assertive, questioning or 'critical' as defined by Bjørndal (2020). Student-teacher comments indicated that college mentors mostly pointed out elements of their teaching they needed to develop and directly told them how to improve, indicating linear dialogue. These findings did not appear to support the reflective practice model that underpins ITE at this institution.

7.2. Cycle 2 Findings

Cycle 1 findings informed a series of professional development sessions. New practice guidelines were developed and implemented during the next period of school-based practice (SBP). Due to the global pandemic this period of SBP was conducted online. Cycle 2 evaluated the professional development and implementation of the new practice guidelines. Cycle 2's findings revealed that the new practice guidelines supported a more consistent and structured approach to giving and receiving PTOF. College mentors indicated that they knew what their roles and responsibilities entailed. The addition of meetings before SBP facilitated student-teachers' understanding of expectations and served to build mentor/mentee relationships. After the interventions, all college mentors indicated that they found the new formative lesson observation template easier to use. It supported their provision of evidence-based feedback to student-teachers during PTOF. Additionally, most college mentors found the PD useful, and the additional resources supported them to give PTOF. Most participants preferred the convenience and flexibility of online PTOF. However, the home environment was not always conducive to student-teacher development and learning. Student-teachers mostly switched off online cameras, explaining that their families would disapprove if they showed their faces. Cycle 2's findings raised concerns that Emirati female

student-teachers who study from home may be disadvantaged. Despite no commuting, a lack of time to conduct PTOF remained a concern in Cycle 2. This suggested serious flaws in the institutional formula used to calculate lesson observation schedules.

There was a transition towards collaborative mentoring and PTOF after the interventions. Most college mentors acknowledged that the PD and new practice guidelines supported this transition. Before the interventions, these college mentors acknowledged that they mostly incorporated directive approaches to PTOF; this transition therefore represented a paradigm shift in their theoretical approach. The findings revealed that removing grades from individual observed lessons supported greater collaboration during PTOF. However, reflective practice was mostly found to be descriptive. Most student-teachers were positive, more relaxed and felt more comfortable during Cycle 2's PTOF than Cycle 1's. While the shift to online delivery likely accounted for some of this sentiment, this change indicated a transition towards collaborative approaches to mentoring and PTOF. However, challenges were experienced when holding learning conversations and giving and receiving assertive, questioning feedback, which were perceived as new practice for approximately half the college mentors. These college mentors found giving grades easier and student-teachers wanted college mentor direction to develop their knowledge and improve their teaching skills. These findings indicated that the participants could have perhaps been better prepared, suggesting directions for future development.

8. CONCLUSION AND RECOMMENDATIONS

Although not generalisable, the findings offer insights applicable to other campuses running the ITE programme. The study recommends continuing the practice of not grading individual lessons, coupled with curriculum revisions to embed PTOF development into the SBP course. Reflective practice and collaborative mentoring should be explicitly taught as part of a developmental approach. While timely PTOF remains ideal, online PTOF should only be used when same-day face-to-face sessions are unfeasible. Institutional observation schedules require revision to address time constraints. Assigning college mentors to student-teachers they teach in class and limiting class sizes could alleviate workloads and enhance relationships. A contextually appropriate mentor development programme is essential, with adequate time allocated for its delivery. Wetzel et al. (2017) emphasise that sustained PD is required for PTOF dialogue to become less directive and more reflective. Future PD efforts should involve all stakeholders—mentors, student-teachers, and the wider community—in a collaborative pedagogical partnership, as suggested by Murphy and Ní Dhuinn (2022). This partnership could extend to developing a similar programme for school-based mentors.

This study demonstrates that Western models of mentoring and PTOF can be adapted to the UAE context but highlights the need for ongoing developmental support to ensure their success.

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Chapter # 3

DEVELOPING PRE-SERVICE TEACHERS' PRAXIS THROUGH A CULTURALLY AND LINGUISTICALLY IMMERSIVE TEACHING EXPERIENCE

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ABSTRACT

Being an effective educator within culturally and linguistically diverse schools requires a rich understanding of how to support students from various cultural and linguistic backgrounds. Historically, teacher education programs have not fully addressed strategies to leverage students' cultural identities and linguistic strengths. Pre-service teachers, particularly those from rural and homogeneous communities, often have limited exposure to diverse populations. However, classrooms today are increasingly global, with students speaking multiple languages and families embodying different cultural norms. To bridge this gap, learning about the intersection of school, community, and families from diverse perspectives is critical. This mixed methods study aimed to provide pre-service teachers with unique and practical experiences to prepare them for teaching students from culturally and linguistically rich backgrounds. Data were collected through daily reflections with open-ended questions and Likert-scale questionnaires. Qualitative data were analyzed using thematic analysis to identify recurring patterns, while quantitative data were examined through descriptive statistical methods. Findings suggest that immersive experiences broadened pre-service teachers' understanding of diversity and equipped them with strategies to create inclusive learning environments. These results highlight the importance of experiential learning in preparing future educators for success in increasingly diverse classrooms.

Keywords: pre-service teachers, cultural competency, international teaching.

1. INTRODUCTION

Teaching is a complex endeavor that requires educators to possess both content and pedagogical knowledge. Part of this pedagogical knowledge is an understanding of the role students' culture plays in the classroom (Klug, 2021). These cultural aspects include such things as their attitudes, beliefs, language, faith, and customs. Given the diversity of classrooms globally, it is important that pre-service teachers have cross-cultural experiences to help them prepare for the reality of teaching. They need to perceive and value cultural diversity in a more positive and strengths-based way and to view peoples of other cultures without stereotyping (Cushner, 2007; Papadopoulou, Palaiologou, & Karanikola, 2022). This means that teacher preparation programs, and the schools that host pre-service teachers for field-based practicum experiences, have a substantial role in helping pre-service teachers understand these complexities. However, many pre-service teachers have limited experiences working with students from cultures other than their own or in supporting students whose home language is different than that of the primary language spoken in school. This means these pre-service teachers are potentially at a disadvantage when they step into their own

classrooms as the teacher of record and need to work with students whose language and culture do not match their own. However, when they are immersed in a different culture, they can develop important skills such as global competency, intercultural sensitivity, and foreign language abilities and pedagogies (Rahatzad, et al., 2013; Wilcoxon, Steiner, & Bell, 2022). Thus, the purpose of this project was to better understand how a culturally immersive field experience promotes intercultural learning and competence, confidence in their teaching in different contexts, as well as pre-service teachers' personal growth.

1.1. Field Experiences in Teacher Preparation Programs

Traditional teacher preparation programs often include some, albeit sometimes limited, opportunities for pre-service teachers to work with K-12 students and to gain experience with designing and delivering instruction as well as assessing learning. Field experiences continue to be one of the most effective strategies for increasing pre-service teachers' effectiveness (Education Commission of the States, 2003; Mak, Yang, & Yuan, 2023) but they often occur during the final stages of their training and only in select schools or contexts. Because of this, pre-service teachers have limited opportunities to develop a deeper understanding of the interplay between teaching and learning in culturally and linguistically diverse settings. As early as 1995, the National Council for Accreditation of Teacher Education (NCATE) recognized the importance of these culturally rich experiences and mandated teacher education programs to provide global and international education (NCATE, 1995); it continues to be of importance today (Romjin, Slot, Leseman & Pagani, 2020). This means that teacher preparation programs have an obligation to the profession, to pre-service teachers, and to the communities they serve to ensure that teachers have the academic and cultural competencies to support all children (Ladson-Billings, 2016). In fact, by under-preparing pre-service teachers for teaching within culturally diverse contexts, negative stereotypes around race, culture and poverty can be reinforced (Santoro, 2014). This further highlights the importance of culturally immersive field-based work.

Furthermore, field experiences create opportunities to develop practices and dispositions that substantially impact teacher effectiveness. For example, field experiences allow pre-service teachers to apply theory in real settings (Bartolome, 2017) and understand the nuances of complex practices such as facilitating whole-class discussions, responsively attending to classroom management incidents and reinforcing classroom norms. All of these complex teacher actions require opportunities to practice, rehearse, or otherwise try out complex teaching practices in authentic situations (Lampert et al., 2023). Likewise, field experiences help shape pre-service teachers' identity, confidence and self-efficacy (Ateskan, 2016) all of which impact their effectiveness as teachers.

1.2. Building Cultural Awareness and Competencies

When pre-service teachers have opportunities to directly interact with people who do not share the same cultural traits or beliefs as they do, or who speak different languages as their first language, or are culturally different within real-life settings, it can promote self-awareness and cultural sensitivity. When such experiences are combined with classroom instruction, pre-service teachers develop a more robust understanding of culture and language, and the role they play in teaching and learning (Macqueen, Reynolds, & Ferguson-Patrick, 2020). However, this awareness of culture, and the role teachers have in creating meaningful interactions and shared cultural interactions, means that pre-service teachers have had experiences where they reflect and think about their own beliefs, values, biases and judgements within an unfamiliar context (Sarı & Yüce, 2020). As they critically analyze their own culture as well as become aware of how human differences are used by

people in power to rationalize inequality and maintain their position of authority in society, they are better able to see students as individuals, coming from different contexts and situations (Smolcic & Katunich, 2017). They then can see that a one-size-fits all method of teaching is potentially ineffective, and come to see that a student centered approach to teaching is necessary.

Teachers' intercultural competence is necessary to teach all students effectively, as teachers must recognize that culture shapes how individuals see themselves and the world around them. Intercultural competence refers to the ability to understand other people across cultural barriers and includes the attitudes, knowledge and skills required to function effectively with those from cultures different from our own (Smolcic, 2013). One way teacher education programs can build cultural awareness and intercultural competency is through immersive field experiences in schools with students from different cultures. In doing so, pre-service teachers have opportunities to interact with other people and to learn about other ways of thinking and being (Papadopoulou et al., 2022). Given the cultural differences often found between teachers and their students (King & Butler, 2015), such interactions become increasingly more important prior to end-of-program, field-based experiences. In addition to an increased intercultural competency, Willard-Holt (2001) found that even in short-term international experiences, participants develop greater global awareness, flexibility and reflectivity in teaching along with a heightened sense of professionalism in collaborating with colleagues and teaching students in other countries. Such professional dispositions are also the hallmark of effective teachers.

Essentially, field-based work in teacher preparation, when viewed through the lens of diversity in culture and language, is essential for developing culturally responsive skills, fostering cultural competence, and preparing future teachers to navigate the complexities of diverse classrooms. As such, the purpose of this project was to better understand how a culturally immersive field experience promotes intercultural learning and competence, confidence in their teaching in different contexts, as well as pre-service teachers' personal growth.

2. DESIGN

This study used a mixed methods approach (Creswell, 2020) as it allowed for interpretations of participants' perceived experiences. The mixed methods approach allows for the development of understandings based on multiple qualitative data sources as well as descriptive statistics. This project is in its second year, and the data and findings in this paper are from surveys and reflections from both years of the project.

2.1. Methodology

The study included data from daily reflections with open-ended questions as well as Likert scale type questionnaires. Likert type questions (scale 1-10) asked each day can be found in Table 1 and other open-ended questions can be found in Table 2. Emphasis was placed on the interpretations and meanings that the researchers had towards developing intercultural learning and competence from these qualitative data in order to identify key themes (Patton, 2014).

Table 1.
Daily reflection questions with Likert response.

Q1. How comfortable did you feel working with students who speak different languages in the classroom?
Q2. How comfortable did you feel engaging with people who do not speak English?
Q3. How comfortable did you feel being in an international setting where English is not spoken?
Q4. How well do you understand the host nation's culture?
Q5. How comfortable would you feel working in an international school?

Table 2.
Open-ended daily reflection questions.

Q6. Based on your experiences today, what are 1-2 things you better understand about Dominican Republic culture, the people, or their way of life?
Q7. Discuss something that happened today that you will share with others?
Q8. When you think about what you did today, what was something that made you feel outside of your comfort zone? What did you learn from that situation?
Q9. What is something that happened today that will impact your understanding of being a professional educator?
Q10. What else do you want us to know as it relates to what we did today?

2.2. Participants and Setting

Participants included 19 pre-service teachers from two years' experiences. In this chapter, we refer to the cohort from 2023 as Cohort 1 (n=11) and the cohort from 2024 as Cohort 2 (n=8). All participants attended a university in a more rural and mountainous region of the United States. Of these 19 participants, 14 of them were focusing on early childhood/primary education (Cohort 1 = 9 elementary; Cohort 2 = 4 elementary/1 early childhood). The remaining six were focused on secondary education (Cohort 1 = 3; Cohort 2 = 3). Additionally, while 14 of the 19 participants had traveled outside of North America, only six (6) had been outside of North America. Participants varied in their progress of completing their program; two were sophomores, 13 were juniors, and 4 were seniors. Additionally, three participants fluently spoke the language of the host nation, which is Spanish. Table 3 shows the focus of the day's activities for each of the cohorts.

Cohort 1 had fewer days in classrooms and a dedicated day to cultural excursions (museums, tours, shopping), where Cohort 2 had more time to acclimate post arrival with unscheduled activities, and had an additional day in classrooms. For Cohort 2, cultural experiences were shorter and spread out over the week. Cohort 1 had four (4) total instructional days in classrooms, and Cohort 2 had five (5) total instructional days. In addition, Cohort 2 took fewer independent excursions than Cohort 1, when given time to explore on their own.

Table 3.
Daily activity focus for each cohort.

	Cohort 1	Cohort 2
Day 1	Travel/Arrival (Sunday)	Travel/Arrival (Sunday)
Day 2	In Classrooms (Monday)	In Classrooms (Monday)
Day 3	In Classrooms (Tuesday)	In Classrooms (Tuesday)
Day 4	Cultural Excursions (Wednesday)	In Classrooms (Wednesday) Cultural Excursions (Wednesday evening)
Day 5	In Classrooms (Thursday)	In Classrooms (Thursday)
Day 6	In Classrooms (Friday)	In Classrooms (Friday)
Day 7	Cultural Excursion (Saturday)	Departure/Travel (Saturday)
Day 8	Travel/Departure (Sunday)	

The host school, the American Island School (AIS), is a private American curriculum school located in the Caribbean and includes students from pre-kindergarten through grade twelve with nearly ninety-eight percent of graduates going on to pursue a post-secondary degree. Approximately 60% of students are citizens of the nation with the other 40% representing nationalities from 31 other countries. While English is the primary language of instruction at the school, nearly 70% of all students are English Language Learners. Though all teachers and school directors speak English, support staff (e.g. custodians, lunch personnel) do not all speak English. Therefore, participants needed to communicate to non-English speakers, particularly during lunch. During instructional hours, participants were placed with one cooperating teacher and were asked to support the teacher throughout the day. By the end of the week, participants were supporting the teacher of record by teaching multiple-mini lessons or an entire class period.

While the majority of the time was spent at AIS experiencing what it means to teach within an internationally, culturally and linguistically diverse context, participants also had opportunities to independently engage with the community. This often meant going out for meals together without university faculty, visiting cultural heritage attractions or museums, or visiting local markets to make purchases. During these times, participants were faced with interacting with locals and trying to communicate their needs or wishes despite not being fluent in the local language. This allowed for participants to further consider the intersection of families and communities within the broader school community.

2.3. Limitations

Due to the low number of participants and the nature of qualitative data, the findings from this study are not broadly generalizable. It is left to others to determine the extent to

which this study aligns with other cases or contexts. However, given the increase in cultural and linguistic diversity of students in schools globally, it is possible that understandings from this study may be applied to other relevant or similar contexts wherein further insights can be developed (Patton, 2014).

3. FINDINGS

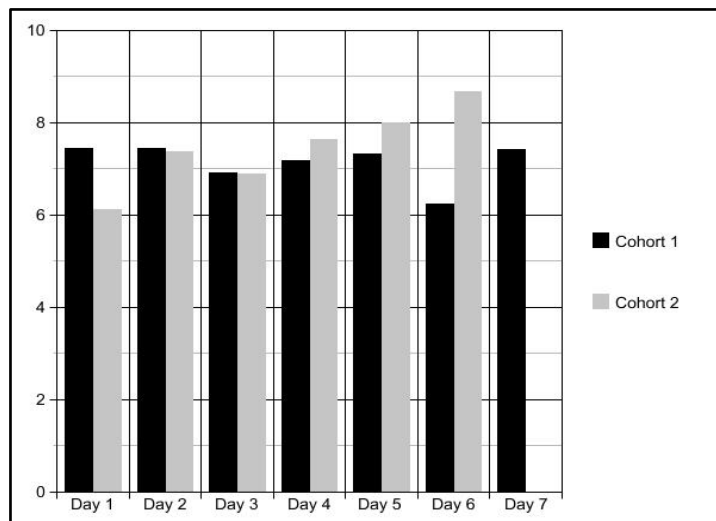
Both the qualitative and quantitative findings are based on the daily post experience reflections. Quantitative data was summarized by question, day and then by cohort. From the analysis of the qualitative data (open ended questions), several themes emerged but for the sake of this chapter, only two of the more prominent themes are shared. These two themes focus on a personal change with respect to: 1) identity, self or professional purpose and 2) an awareness of culture in teaching and in learning.

3.1. Changes in Comfort

Responses to survey questions for both cohorts showed that for all questions, pre-service teachers self-assessed higher at the end of the experience compared to the first day; as might be expected. The pre-service teachers felt more comfortable over time working with students who speak different languages in the classroom (Q1), felt more comfortable engaging with people who did not speak English (Q2) and being in an international setting where English was not spoken (Q3). Additionally, the pre-service teachers felt they gained a better understanding of the local/national culture (Q4) and felt more comfortable working in an international school context over the course of this experience (Q5). As shown in all figures below, Cohort 2 showed a more substantial positive gain over time compared to Cohort 1 despite having initially lower scores in all questions.

Figure 1.

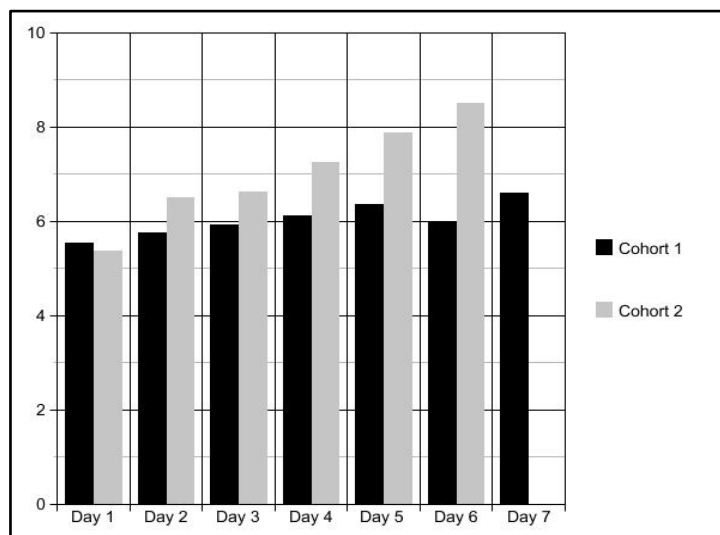
Q1: How comfortable did you feel working with students who speak different languages in the classroom?



With respect to comfort and confidence engaging with others who speak another language (see Figure 1), pre-service teachers from Cohort 1 initially self-assessed higher than Cohort 2 in these three questions, most notably in Question 1. When cohort data is desegregated for Question 1, Cohort 1 is generally consistent across all days with small variations from day to day; scores do not change much over time. However, Cohort 2, while lower than Cohort 1 on Day 1, shows a more positive upward trend across days with a higher overall score on Day 7.

Figure 2.

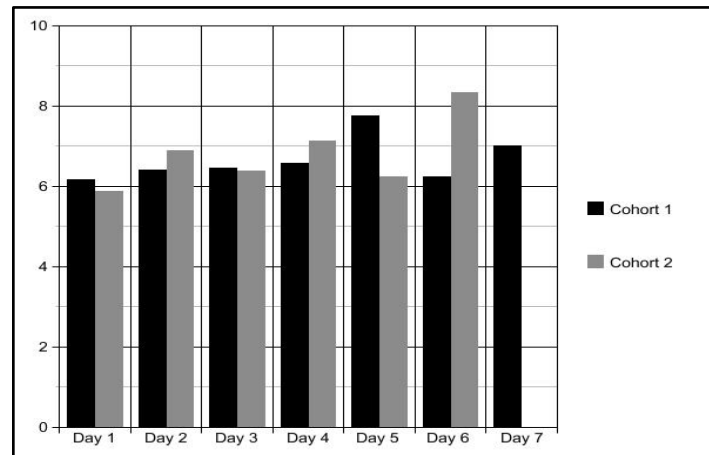
Q2: How comfortable did you feel engaging with people who do not speak English?



For Question 2, which focused on pre-service teachers' comfort with engaging people who do not speak Spanish, be that in the school community or the local community, Cohort 2 again showed a more positive upward trend over time compared to Cohort 1 (see Figure 2) even though Cohort 1 had an additional day to interact with people in the local community, as previously shown in Table 1. While the change for Cohort 1 showed a slightly positive gain over time, the small changes are minimal at best and even show a drop in their overall comfort on Day 6.

Figure 3.

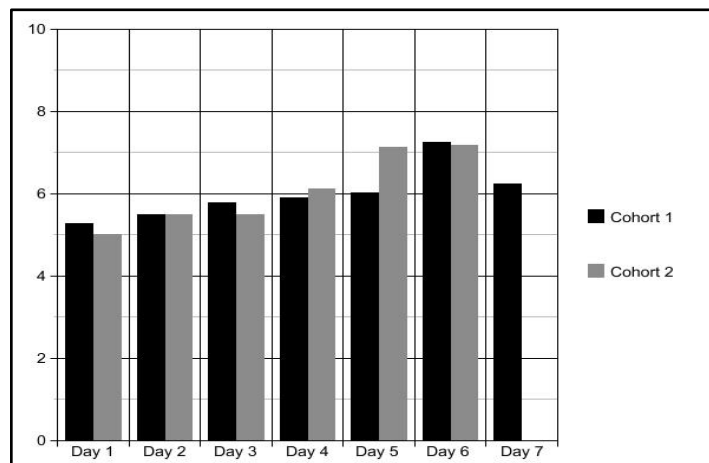
Q3: How comfortable did you feel being in an international setting where English is not spoken?



As for pre-service teachers' comfort with being in an international setting where English is not spoken, the responses generally show a positive increase over the course of the experience, with a slight drop for Cohort 2 on Day 3, and a drop on Day 6 for Cohort 2 (see Figure 3). While the scores for Cohort 2 twice dropped from the previous day, the growth from the first day to the last day was greater than Cohort 1. This is a continuing trend, with respect to their interaction and engagement with others who do not speak English, across all three questions. And while the average score for Cohort 1 would show that they also had a positive change in their self-assessed comfort levels, there is a clear outlier on Day 5; most scores across days generally show little to no change.

Figure 4.

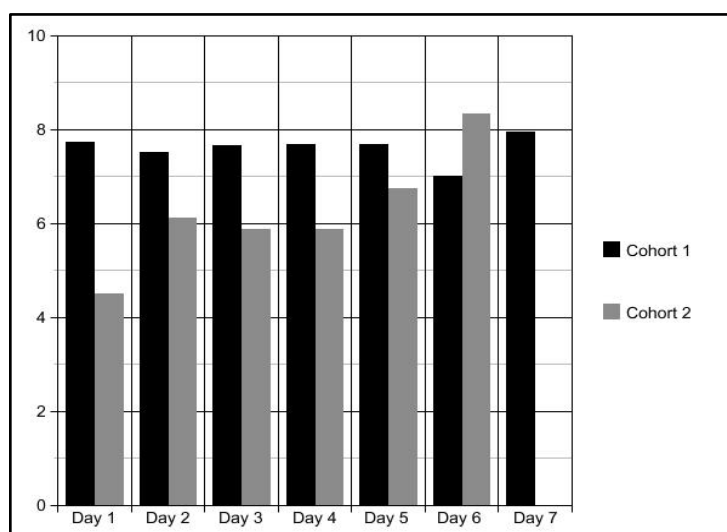
Q4: How well do you understand the host nation's culture?



With respect to pre-service teachers' understanding of the host nation's culture, both cohorts generally self-assessed a greater comfort over the course of the first six days (see figure 4); both show a positive increase in their perceived understanding over time. However, Cohort 2 had a noticeable increase on Days 5 and Days 6, which were the final two days of their immersive teaching experience, while Cohort 1 had a noticeable difference on day 6. While it is unclear why this increase occurred on the last day, it may be related to their final day with students in the classrooms; reflecting on a positive experience within the local and national culture. While there is a drop on Day 7 for Cohort 1, the cultural experience on Day 7 had them interact in more personal ways with people who were not financially secure. The pre-service teachers' interactions with these individuals, and the resulting reflections on what day to day life may be like for these people, may have influenced their scores for that day.

Figure 5.

Q5: How comfortable would you feel working in an international school?



Lastly, when considering pre-service teachers' level of comfort working in an international school (see Figure 5), Question 5 shows the teachers from Cohort 1 self-assessed higher at the beginning than Cohort 2, but Cohort 2 again showed more growth over time. Likewise, Cohort 1 had generally consistent scores that show little to no change over time and Cohort 2 showed a more positive upward trend in their scores across the immersive teaching experience.

Collectively, the quantitative data indicates that changes in scores for Cohort 2, across the experience and regardless of question, followed a similar pattern; there was a clear upward trend for all questions. Whereas for Cohort 1, changes in scores across time were either marginal or relatively unchanged. While the structure of the experience was similar for both cohorts, there are some notable differences, discussed below, that may shed light on this data.

3.2. Change in Identity, Self and Professional Purpose

Through analysis of the qualitative data, some major themes emerged. The first major theme is in relation to participants' perceived change with respect to their purpose in the profession or in how they perceived themselves. Collectively, participants wrote about this experience as being a major transformative process that had an impact on them in one of these ways; it was reported often as a "life changing" experience. Many also wrote about a new found joy for teaching. "There is a fire in my heart once again for teaching," and they came away "with a new outlook and renewed passion for teaching" wrote two participants. This suggests that even short-term immersive experiences can impact pre-service teachers' views of teaching.

Others recognized a substantial change in their own identity or shift in their own self-confidence. One participant stated they came back "no longer quiet and small, but confident." Whereas another wrote that "when I got off the plane, I was not the same person who got on the plane a week prior." Others indicated they were surprised with themselves because they were in new situations and had to adapt to these situations, which took a kind of courage that they did not know they had. "I just had to jump in, [I] have to be brave." These reflections indicate that personal growth, confidence, and nuances in identity can also be developed and strengthened within intense and immersive field-based experiences.

Others discussed more subtle, and perhaps a more profound understanding about commonalities across cultures. One participant reflected on an evening sitting in the plaza watching families interact and the children at play and how this reminded them of a greater connection regardless of culture and language.

"As I watched these people living their lives and enjoying an evening with family and friends, I was struck with gratitude for this opportunity. I had spent an entire week getting to know the people. I attended their school, ate their food, tried to speak their language, and learned about their history, music, and dance. This significant moment at the plaza was a point of reflection and understanding about what it means to be human."

Collectively, this immersive experience impacted each participant's sense of self, identity and their personal purpose, which were not inherently a focus of the project.

3.3. Cultural Awareness in Teaching and Learning

The second major theme centered on a cultural awareness, specifically in aspects of teaching and learning that they did not previously have or did not fully appreciate prior to the experience. While this immersive experience was only one week long, it seems to have been enough for them to understand the important role community, culture and language play in teaching and learning. One participant wrote "I learned what it was like to feel like an outsider and to be in the minority" whereas another reflected that "I will hopefully be able to help students of diverse backgrounds feel accepted, loved, and welcome because I know better what it's like to be in a new place and to stick out." This awareness of cultural diversity and individual differences is something that can be included in coursework but can be difficult to fully process without experiencing it first-hand.

Some developed a more practical understanding of how culture and language impact learning. One participant elaborated on this when they wrote "our culture is what drives us. This culture also [gives] students a sense of identity and purpose. For this reason, it is my profound belief that a child's culture should be embraced in the classroom." Others pointed out how being able to speak to all students was something they had taken for granted. "I now understand what it is like to be in a school setting where the language that is spoken is not your native language," which was something they had not previously experienced. Others wrote about how they began to understand what it meant to create a successful learning

environment for English Language Learners because they were able to have discussions with teachers about specific interventions and then immediately try these interventions with students. "I saw a struggling student learn a new skill and saw the happiness he felt when he knew he could do it." This pre-service teacher went on to state "this is what I want to be able to do for all my students when I become a professional educator."

Likewise, participants were able to also see that along with cultural differences, there can be cultural similarities even when there are appearances of differences. "These people were just like the people I interact with on a daily basis at home. I could see the light of humanity in their eyes. As different as everything felt, it also felt much the same." And as simple as it may sound, several talked about how they began to realize that despite where children live, what they wear, or what language they speak, they share many things in common; "No matter where you go, kids are kids." From this shift in perspective that "even though we are all different, we are more similar than we realize," participants recognized that their role as a teacher remains the same regardless of a child's culture or language.

4. IMPLICATIONS & FUTURE RESEARCH DIRECTIONS

All pre-service teachers, without exception, reported the trip had impacted them in a powerful way, and that they had experienced significant personal and/or professional changes. Culturally immersive experiences empower pre-service teachers to apply the theoretical knowledge they gained from coursework in authentic educational settings to better understand the interplay between theory practice. This seems to also be the case with respect to culturally responsive teaching. And while traditional teacher preparation programs are often designed to balance theory and practice, some teaching attitudes, beliefs, and skills may be challenging to learn without a more immersive experience wherein pre-service teachers and students can learn from each other (Ladson-Billings, 2016). Likewise, complex topics, such as culturally responsive teaching, require experiences in which one is not from the dominant culture but these experiences need not be semester-long study abroad experiences (Jones & Bond, 2019); short-term immersive experiences can also impact one's cultural awareness. Shorter trips can also be beneficial since they can increase the number of pre-service teachers who can participate. Likewise, participating pre-service teachers can also share their learning with their peers back home which may lead to an even further reaching, and rippling effect on the global education of many future students.

While there may be differences between individual students (i.e. comfort traveling abroad, life experiences, age or purpose for participating) and different characteristics for each cohort, the natural group dynamics that are formed when people meet for the first time, the implication of these influencing factors on the data are unknown. However, there were some notable differences between the structure of the experience that may have impacted the data and thus the implications gleaned from the data.

For example, the experience for Cohort 1 occurred after the end of their academic year and the pre-service teachers had few other personal obligations to attend to and no additional academic obligations. This may have created a more "vacation-like" experience for them in some ways. Whereas for Cohort 2, the experience occurred during the middle of the academic term and the pre-service teachers more often returned to the hotel to work on other academic obligations for other courses, and were more immersed in learning as part of their academic program.

Also, for Cohort 1, the two cultural excursions were equally spaced across the immersive experience, which then disrupted their time and exposure to students, teachers and working within an international school context. Cohort 1 only had four days at the school,

compared to the five for Cohort 2, and these four days were broken up with a cultural experience in between. While additional cultural experiences may seem to be a beneficial opportunity to learn about the host nation or to interact with others who speak a different language, it is unclear that this was the case when comparing the two structures for the two cohorts. In fact, the data from this small study might suggest that a more cohesive and continual experience in the school may have helped the pre-service teachers grow across all areas of the project.

Additionally, for Cohort 2, enhanced cultural and language challenges were encouraged. For example, the faculty leaders of the experience told the pre-service teachers that they could not rely on the Spanish speaking pre-service teachers in the group to order lunch or dinner. While all teachers and professional staff at the school spoke English, the custodians and lunch servers rarely did. The pre-service teachers were instructed to interact with these people however they needed to in order to get what they needed, such as what they wanted for lunch, or they could ask a student at the school to help them. The intent was to force them to have experiences interacting with others even though they could not speak the language. While this was intimidating and created a level of anxiety at first for the pre-service teachers in Cohort 2, they eventually expressed great pride in ordering their lunch, something as simple as “may I please have chicken and rice” by day three. Something as simple as ordering lunch, and the initial uncertainty that came with this “challenge,” may have helped the pre-service teachers in this cohort be more confident and comfortable in culturally immersive experiences.

5. CONCLUSION

One aspect of effective teaching includes being culturally responsive and possessing a cultural competence to support all students. For some pre-service teachers, their limited experiences working with students from culturally, linguistically or ethnically diverse settings means they have ways of thinking about teaching and learning that are underdeveloped. When teacher preparation programs and the schools where pre-service teachers are placed for field-based practicum do not work to address these deficiencies, pre-service teachers are then at a potential disadvantage. With the shift in student demographics changing in schools across the globe, the need to prepare pre-service teachers for different kinds of diversity becomes even more important. This study showcases the impact that even small, immersive opportunities can have on pre-service teachers’ cultural competencies, empathy, and awareness of students’ cultural and linguistic strengths. And as such, the potential to “open minds” to the possibilities of culturally responsive teaching takes root.

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Chapter # 4

THE ELECTRONIC GRADEBOOK ALTERNATIVE: The Custom-Made Course Administration Spreadsheet

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ABSTRACT

Instructors at all educational levels are responsible for a variety of course-centric administrative duties, which typically include taking attendance, planning lessons, marking and recording homework and other assignments, and calculating students' grades at the end of a semester. While many instructors are drawn to the numerous commercial and open-source electronic gradebooks available to aid with the implementation of such duties, they may only later realize their drawbacks, which can include their being time-consuming to learn, inflexible, inoperable after operating system upgrades, or insufficient in terms of certain desired features. There is no one-size-fits-all electronic gradebook solution, but the often-overlooked gradebook alternative that counters many of these drawbacks is the custom-made course administration spreadsheet. The present chapter seeks to illustrate through explanation and example the reasons and methods by which such spreadsheets can offer instructors effective and adaptable tools for handling their course-related administrative requirements.

Keywords: electronic gradebooks, spreadsheets, teacher administrative duties, student data.

1. INTRODUCTION

The responsibilities of educators are legion. Beyond the teaching of lesson content, instructors are tasked with dutifully keeping records of course-centric information, which includes but is not limited to student attendance information, homework scores, quiz grades, and final exam results. This student data (hereafter, SD) is used primarily by instructors to determine students' semester- or year-end grades, but it is also often required by educational institutions for myriad purposes (e.g., for student academic progress assessment, pedagogical policy and course curricula review, future funding procurement). As such, with the tasks of collecting, organizing, processing (e.g., calculating final grades), and analyzing SD being seen as paramount, instructors should strive to engage and complete these tasks in the simplest, most efficient, and least stressful manner possible.

With the history of personal computers and the internet now spanning decades, there have long been arguments for instructors to transition from traditional pencil-and-paper SD-tracking methods to digital data handling solutions (DDHSs) due to the latter's many apparent advantages (see Hafner, 1992; Vockell & Fiore, 1993). Continual technological advances and the widespread adoption of digital devices like iPads have sustained these arguments, which have been supported not only by the numerous teacher-oriented websites promoting and/or selling such solutions but also those investigating the topic and publishing their findings in academic literature (e.g., Shaw, Pedersen, Cooley, & Callingham, 2013; Vogel, 2022; Zach, 2005). Indeed, as Vogel (2022) points out, electronic gradebooks (i.e., DDHSs) offer significant advantages, as they can easily store and calculate student assessment data. By automating data preparation, processing, and analyses, instructors can not only minimize their time spent on administrative tasks, but they can also focus more of their time and attention on enhancing the quality and quantity of their teaching (Jasińska-Maciąg, 2020).

2. BACKGROUND TO DDHS SELECTION

As there are various types of and use-case scenarios for DDHSs, instructors must consider and weigh a variety of factors prior to DDHS selection, the most common ones being:

- **Overall purpose.** Is SD limited to grade tracking and processing, or does it include other data (e.g., attendance data, seating chart information)?
- **Cost.** Is the DDHS free? If not, what is the payment structure (e.g., a one-time purchase price, a yearly subscription fee)?
- **Features.** Does the DDHS have one's preferred or required features to maximize its utility and justify its use?
- **Intuitiveness and ease of use.** Is the DDHS designed in a way that matches the potential user's sensibilities?
- **Instructional guidelines.** Are there any limitations or restrictions imposed by an instructor's educational institution on DDHS selection or use?

The author of the current chapter examined various DDHSs, which included many well-known and popular ones such as Gradekeeper, iDoceo, Additio, ThinkWave, Google Classroom, and Microsoft Excel spreadsheet templates. These and other commercial and open-source DDHSs, having been specifically created by software developers and educators to aid instructors in recording and utilizing their SD, typically function just as intended. Considering (a) the diversity of educational environments, (b) instructors' various SD-handling requirements, and (c) instructors' preferences based on their specific pedagogical approaches and often unique teaching contexts, no DDHS exists that could possibly be appropriate for all scenarios involving SD recording, managing, and processing. Even so, the above-mentioned DDHS examination has singled out an often-overlooked solution: the common spreadsheet.

It is understandable that, at first glance, spreadsheets may seem more appropriate for non-educational use cases (e.g., budgeting, accounting, inventory control). Being general rather than specific in nature, the simple spreadsheet may appear less suitable for managing SD compared to other electronic gradebook options. However, technology utilized for course purposes should be viewed as a tool (Martin, 2022), and as such, the tool should provide certain expected benefits. A DDHS need not necessarily be complex or costly for use in educational settings. Indeed, as is argued here, instructors employing a spreadsheet of their own design can reap numerous benefits, and depending on their unique situations and requirements, they may discover further significant advantages should they choose the approach of creating and utilizing their own electronic gradebook spreadsheets.

3. COMMERCIAL VERSUS CUSTOM-MADE SPREADSHEET GRADEBOOKS

It must be reiterated from the outset that no DDHS is inherently better or worse than any other. DDHS selection comes down to understanding and considering a range of factors and weighing the benefits and drawbacks of each against their use-case scenarios. Why a custom-made spreadsheet should be considered a viable choice can be illustrated by relating the various benefits and drawbacks to the different types of DDHSs available for

use. Although far from exhaustive, the following lists the advantages and disadvantages of each type.

Commercial software benefits include:

- **Common tasks are built in.** Most include features to track and process SD, such as attendance data, seating chart information, assignment scores, and final grades.
- **Overall wide variety.** With many choices available, instructors can often easily test and evaluate which DDHS option might best suit their purposes.
- **Troubleshooting assistance.** Commercially available DDHS software should have avenues available by which instructors can solve any usage problems.

Commercial software drawbacks include:

- **Lack of timely updates.** This could be catastrophic, especially after operating system (OS) updates. A DDHS may become completely inoperable if it is not updated for use on the new OS.
- **Discontinuation.** Sellers may stop developing their software, sometimes without warning. This leads to inevitable incompatibility with future OS versions and risks SD that has been archived in a proprietary format becoming inaccessible or unretrievable.¹
- **Limited platform availability.** Some software may be Windows-only, or it might not function on specific devices (e.g., iPads).
- **Upfront and/or hidden costs.** Few are completely free. Even if bought via a one-time purchase, it is possible for developers to later switch to a subscription model, which may be too costly for individual instructors to sustain.
- **Customizability limitations.** Many DDHSs are inflexible in terms of how they allow data to be entered, displayed, and processed. Restricting the customization of minor yet desired aspects of a DDHS can become a huge impediment in the efficient handling of SD.
- **Inelegant documentation.** This could come in the form of overly concise or overly exhaustive manuals (see Vogel, 2022).
- **Regional limitations.** There may be some features that are only available for use within the DDHS's country of origin.

These are not the only drawbacks to such commercial software. Instructors should also be aware of several additional points:

- Time must be devoted to DDHS investigation and familiarization (e.g., features, compatibility in specific use-case scenarios).
- Instructors will necessarily be forced to repeat the investigation and familiarization process should they wish (or be forced) to switch to a new DDHS.
- Some DDHSs may lack intuitiveness or otherwise clash with a user's sense of aesthetics.

Custom-made spreadsheet electronic gradebooks also have benefits and drawbacks. Their advantages can be seen in the following:

- **Overall customizability.** Instructors decide the type of data to be collected and how that data will be input, displayed, and ultimately processed. Visual elements for data

comprehension purposes may also be utilized. In other words, specific data may be made more distinguishable by giving it a unique cell color or by placing it in a certain location. Adjustments to spreadsheets (e.g., appearance, formulas to be used) may be made as needed.

- **Nearly guaranteed non-obsolescence.** This is particularly true for spreadsheets made with software developed by Microsoft and Apple (see below), as there is every reason to believe that their applications will continue to be updated and enhanced indefinitely, with backward compatibility with previous versions included.
- **Troubleshooting assistance largely unnecessary.** The spreadsheet is user-constructed, meaning the user is cognizant of every facet and function (i.e., the formulas used for SD processing purposes) found within. Most problems, difficulties, or general queries can be solved or answered by a simple internet search.
- **Online templates available.** If instructors do not wish to start building their spreadsheet from scratch, they have the option of downloading free templates from the internet and tweaking those to their satisfaction.

Like their commercial counterparts, custom-made spreadsheets have their share of shortcomings:

- **Possibly time/energy intensive.** Spreadsheets may require substantial time and energy to construct, though this is dependent on the level of complexity and amount of visually distinguishing features desired. Those wholly unfamiliar with spreadsheets would likely require additional time for familiarization purposes.
- **Potentially challenging or intimidating.** This is particularly true for first-time spreadsheet users or those unsure of the various spreadsheet functions available.
- **Lack of desired features.** Spreadsheets are not specifically designed as course-centric SD managing software. As such, they may not include specific features commonly found in commercial gradebook software (e.g., collaboration tools, online accessibility for students/parents).

The selection of a DDHS is without doubt a serious responsibility requiring significant diligence. Instructors should be as informed about their DDHS choices as possible before they decide to commit to one, and they must understand and weigh their DDHS preferences and desires with their real-life use-case situations. Because all teaching in formal educational contexts involve SD collection and processing, instructors are strongly advised to thoroughly evaluate their DDHS options and implement the solution that best suits their needs as soon as possible.

4. THE SPREADSHEET

In this section, custom-made course administration spreadsheets (hereafter, CMCASs) will be explained. This explanation should prove enlightening to those wishing to learn more about how spreadsheets may be used as a DDHS as they weigh their DDHS options.

4.1. Spreadsheet Background

Before delving into the specifics of CMCAS construction and use, several preliminary points must be relayed. First, the CMCAS discussed here should be thought of as an example CMCAS only, albeit one set up for a specific type of course (in this case, a

university-level course where SD such as mid-semester grades and attendance information need not be shared online with students or parents²). Second, its appearance and utility as described here may not fully align with readers' expectations, preferences, or requirements. This is not a concern, as this chapter aims to present an example use-case scenario for illustrative purposes. Readers are encouraged to utilize the explanations provided here to develop their own CMCAS (i.e., one tailored to their own specific needs), or at minimum use the information presented here to more critically evaluate commercial or other gradebook options.

Third, readers are expected to possess a basic understanding of spreadsheets (e.g., menu bar items, toolbars, headers and footers), as detailed explanations of a typical spreadsheet's various elements are beyond the scope of the current chapter. Lastly, only fundamental functions (i.e., formulas used for automated calculations) are utilized and explained here. Much variation exists in instructors' spreadsheet needs and technological skills (Bennett, Maton, & Kervin, 2008), so that which is presented here is a simple CMCAS suitable for explanatory and illustrative purposes. Instructors may later explore and add more complex functions at their discretion.

With the current chapter providing only basic spreadsheet explanations, those considering implementing CMCASs are strongly encouraged to first ascertain what SD need to be recorded and processed. For instance, must student attendance be tracked? If so, are late students penalized (e.g., three tardies equal one absence)? Are students allowed to drop their lowest quiz grade? Does the educational institution require descriptive statistics for the students enrolled in a course (e.g., average grades, minimum and maximum final exam scores)? Spreadsheets could easily perform all these tasks and more, but it is the duty of the CMCAS creator/user to determine where these functions are to be included and how their output is to be presented. There is ample documentation available on the internet, including dedicated webpages and video tutorials, to aid CMCAS designers in configuring their spreadsheets.

As a supplement to the current discussion, the CMCAS described in this chapter is accessible as a template (in different formats) found at the following website, which is enclosed within brackets: [<https://www.isc.meiji.ac.jp/~rubrecht/CMCAS/index.html>]. Readers are encouraged to visit the website to gain a comprehensive understanding of the CMCAS detailed in the following sections. Furthermore, readers are granted unrestricted use of this example CMCAS template (which is occasionally updated) and may modify it in whichever ways they deem fit.

4.2. Spreadsheet Programs

Should a CMCAS be chosen as a DDHS, instructors must then select a spreadsheet program. There are numerous options from which to choose, with each offering distinct advantages and limitations that cater to different preferences and needs. Listed below are several common spreadsheet software choices:

- **Excel (Microsoft):** Widely recognized as the standard in spreadsheet software, Excel is available for both Mac and Windows platforms. It typically requires purchase, though many academic institutions provide it for free to instructors. Excel is renowned for its robust functionality and versatility in handling complex data sets.
- **Numbers (Apple):** Available exclusively on Mac (though compatible with Windows once converted to Excel format), Numbers is a free alternative known for being user-friendly and visually appealing. It offers seamless integration with other Apple devices through iCloud, ensuring automatic syncing across devices.

Compared to Excel, Numbers may have limited capabilities for advanced data manipulation.

- **Google Sheets (Google):** This free cloud-based solution allows collaborative work and real-time updates, but only with an internet connection. Its features do not extend far beyond basic spreadsheet functionalities.
- **OpenOffice Calc (Apache):** As part of the free OpenOffice suite, Calc is available across multiple platforms and offers basic spreadsheet functionalities, though these are even less robust than those of Google Sheets. Users may face challenges when manipulating large complex spreadsheets and may experience compatibility issues when sharing files.

The CMCAS discussed in this chapter (and the original version of the template as found on the author's website) is an Apple Numbers spreadsheet featuring multiple sheets.³ Numbers was selected because of its aesthetically pleasing visuals, future-proofness, and automatic syncing and use through iCloud. Also, the author has no need to utilize "open" (i.e., online) gradebooks.⁴

4.3. Spreadsheet Basics

For the uninitiated, there are several fundamental aspects to spreadsheets.

- **Sheets:** It is strongly recommended to construct/use a CMCAS that contains multiple sheets, with each one designed to store/display/process a specific type of SD (i.e., attendance tallies, lesson plans, homework grades, semester-end final grade calculations).
- **Headers:** It is crucial that column and row headers are "frozen" or "locked" to maintain on-screen visibility. Their content may be tailored to suit instructor preferences and course requirements, but left-hand column headers are commonly used to display student identification details (e.g., names and student numbers, which can often easily be imported from XLS or CSV student roster files often provided to instructors by educational institutions) while top header rows are usually used to show category information (e.g., lesson dates, homework assignment names).
- **Fonts, lines, and cells:** Their formatting and presentation are crucial to the visual aesthetics of the CMCAS. As such, it is strongly recommended that uniform (i.e., standardized) font types, sizes, and border styles be used throughout. Doing so reduces CMCAS construction time, increases overall readability, and eliminates style disparities when copying and pasting within and across sheets. It is also advisable to limit differentiation within cells to *changes in font or cell color only* rather than altering font type or cell borders (e.g., border type, width, color).
- **Printing, uploading, and sharing:** Instructor preferences and specific teaching contexts will dictate if (a) any CMCAS sheets will be printed, (b) the CMCAS will be placed in the cloud, or (c) others (i.e., stakeholders) will be granted access. Each option carries its own set of advantages and drawbacks. For instance, cloud storage allows for accessibility across various devices (e.g., on classroom desktops or iPads via services like iCloud) and eliminates the need for later input of handwritten data (e.g., attendance information). However, an online-only CMCAS comes with several potential (and possibly significant) drawbacks. Access may be blocked or hampered by personal or technical issues (see Shaw et al., 2013). Instructors' constant attention

to digital devices to record SD can become a distraction for all course participants. Additionally, there is always the risk of data corruption/loss, which leads to additional time/energy/financial concerns with the creating, maintaining, and storing of backups.

5. THE EXAMPLE CMCAS

The various sheets of the example CMCAS template will now be briefly explained. Readers should note that the space where the left-hand and top headers overlap is a space reserved in each sheet for course identification purposes (e.g., instructor name, course name, course day and period).

5.1. The Attendance Sheet

This attendance sheet (or more literally in this case, the class contribution sheet) is the first of the sheets, as students' attendance data must be collected each lesson. As is evident in the template, the left-hand column contains student identification information while the top header rows contain data identifiers, for instance, lesson dates and grading criteria associated with attendance (e.g., punctuality).

Of special note is that this sheet—like most of the CMCAS sheets in the template—has allocated full marks to all students for *each grading criterion* prior to course commencement. This is done as a time- and energy-saving measure. Instead of individually inputting data into each cell for every criterion for each student each lesson, adjustments (i.e., reductions in marks) to preexisting full-mark data are made only if a student does not meet expected performance standards. Depending on the sheet these adjustments may be implemented either by copying the color-coded cells with predetermined values from the lower-left section of the left-hand header into the corresponding cell (e.g., as seen on the attendance sheet) or by manual input (e.g., as seen on the exam sheet). Pre-made color-coded cells are not strictly necessary, but their use allows for quick identification of criteria where marks have been deducted.

A further advantage of a CMCAS over other DDHSs is that specific cells in various columns and rows may be used to include notetaking spaces. On the attendance sheet, memo space is included for each lesson date in columns adjacent to students' attendance grades. Here, one may record reasons a student was absent (e.g., participation in an intercollegiate tournament) or keep track of specific and possibly recurring problems (e.g., when students continually sleep in class or come to class without textbooks or dictionaries).

To the far right of this (and other scored sheets) is a space for students' tallied scores. A simple sum formula adds up each student's individual grading criterion (e.g., punctuality), and these are then added together via another simple sum formula to compute each student's overall class contribution score on this attendance sheet.

Check spaces (i.e., cells) are also included in strategically placed locations in this and in all other sheets. These spaces are to be ticked only when the accuracy of data input has been confirmed. This becomes especially useful and important when sheets are printed for classroom use (i.e., when handwritten SD is later transferred to the digital CMCAS).

By way of explanation, the author employs a hybrid approach and regularly prints only this attendance sheet at the beginning of each semester. This practice presents several distinct advantages. First, considering the perceived significance and repetitive nature of attendance taking, particularly in the context of remote teaching and learning during the COVID-19 pandemic (see Rubrecht, 2020, 2021a, 2021b, 2021c), it is advisable to use a

simple, low-tech, and unobtrusive method for recording attendance and other common grading criteria. Since attendance must be recorded each lesson, having this attendance sheet readily available in printed form can help avoid potential issues such as internet connectivity problems, technological glitches, or keystroke errors. Second, using a printed sheet eliminates the need to divert attention away from a computer-centric activity (e.g., a PowerPoint presentation) to input attendance data into the CMCAS.⁵ Third, a printed sheet facilitates quick, easy, and accurate sharing of attendance information with students, for instance, when they ask to verify their number of absences toward the end of a semester.

5.2. The Lesson Plan Sheet

Many instructors are tasked with creating detailed lesson plans for a course. Including such plans as a dedicated CMCAS sheet presents several advantages. First, switching from one sheet (e.g., the homework sheet) to the lesson plan sheet aids organization, as both sheets are within the same spreadsheet, which eliminates the need to switch applications. Second, occasionally the order of lesson activities needs to be changed, that is, activities that were planned to be carried out at a specific time can be moved up or postponed. As lesson activities are written individually in rows within a sheet, they can effortlessly be reordered by drag-and-drop. Third, completed lesson activities can be marked with a tick (as explained above), which provides users a clear visual indication of course activity completion. Fourth, these sheets can be easily reviewed and reused in subsequent semesters, with modifications to the order or the planned activities themselves made as necessary.

While printing this particular sheet remains an option, accessing it solely on a digital device offers specific benefits, including (a) quick and unobtrusive checking as a lesson transitions from one topic or activity to another and (b) ease of sheet construction, as sheet layout (i.e., row height, column width) requires only minimal attention.

5.3. The Assigned Activity Sheets

Just as there is an attendance sheet, there should also be corresponding sheets for the other components of a course, for instance, homework, quizzes, projects, and final exams. These sheets can be constructed in one of two different ways, depending on the nature of the various tasks and activities involved, as well as on instructor preferences.

5.3.1. Method 1: Empty Cells

This method is best used for planned assignments (e.g., homework or quizzes) that, for whatever reason, *may possibly not get assigned or carried out* during a semester (e.g., because of time constraints). For this method, a sheet is created that has three distinct header rows. The top row lists the names of that grading component's various planned assignments across columns. The row beneath that notes the maximum score possible for each assignment, for instance, "20," "28," "16," and so on. These maximum assignment scores are summed via a function in a column on the far right to indicate the *total expected points* for that grading component. The next row below has cells left empty. These are also to be filled with each assignment's maximum possible score, but each is input *only as each assignment is completed*. As these figures are also summed in a column at the far right, instructors need only look at this sum to determine the final component score for final grade calculation, thereby minimizing incorrect total possible score calculations.

Unlike the attendance sheet, all student activity score cells for a sheet such as this should be filled in individually via typing (or possibly by copy-and-paste) as grading is completed. This is because the span of possible grades is often extremely wide, for instance, from 0 to 20, 0 to 28, 0 to 16, and so on.

5.3.2. Method 2: Range/Completed Cells

This method is best used for grading components like major projects or final exams where individual aspects may be given a range of grades, for instance, a final exam with exam questions that are graded on multiple criteria (see sample template). Using a fictitious English course writing exam as an example, one row in the top header is dedicated to listing the details of what is to be assessed for each question of that exam. For example, for part of the exam, students are expected to write two English sentences, and those sentences will be checked for grammar, vocabulary, and overall coherence. The row below will list the *range of possible scores* (e.g., 0 to 3). The student score cells below will be populated with a score of 3 *prior to grading* and will only be changed should point deductions be required.

However, on this example exam, students are also being tested on their knowledge of specific vocabulary words that were taught to them in the course. As the grading for these questions are binary in nature (i.e., students' answers will be judged to be either correct or incorrect), the maximum score for each question is inserted in the header row (e.g., a score of 3), and the student score cells are all pre-populated with this same maximum score. Only the answers deemed incorrect require instructor intervention, with those scores of 3 being changed to 0.

5.4. The Final Calculations Sheet

At semester's end, all grading criteria from the various course components must be compiled, appropriately weighted, and summed to calculate each student's final score and/or letter grade for the course. To facilitate this process, a dedicated sheet for processing final scores should be created. This sheet consolidates the tallied scores from the course's various sheets. Each score is multiplied by its designated weight or percentage and then summed to determine final grades. Utilizing separate simple functions for these calculations is strongly recommended, as it ensures accuracy and efficiency in determining final scores.

6. DISCUSSION

As it is not specifically designed to be a DDHS, it is understandable that some instructors would prefer to tolerate deficient commercially available software rather than spend any amount of time and energy constructing or refining various sheets in a CMCAS. This is particularly true for non-tech-savvy instructors or those experiencing burnout. Nevertheless, it is speculated that instructors overlook the spreadsheet due to its reputation as being little more than number-crunching software, which unfortunately is undeserving and undermines its potential to be taken seriously as a serviceable DDHS.

The CMCAS described here should be taken as an example DDHS only and should in no way be considered suitable for all instructors in all teaching situations. It is but one possible way to manage course-centric administrative tasks, and the explanations presented here should at minimum spur instructors to consider ways to better streamline their various administrative duties and ultimately find a DDHS that works best for them.

In closing, the relaying of several final points and recommendations will serve to round out this explanation of DDHSs.

- **Needs evaluation.** First and foremost, instructors should determine their DDHS requirements.
- **Aim for simplicity.** Gradebooks should be user-friendly. Unnecessary complexity (particularly with formula or function use) should be avoided.
- **Trial and inspection.** If a CMCAS is chosen for use, first create a trial version. Examine all aspects of it carefully, including sheet number and type, functions to be included, and the standardized font and colors to be used throughout. Only then should it be made into a template for use across courses and semesters.
- **Partition whenever possible.** The CMCAS as explained here has multiple sheets for a reason. Each sheet serves a specific purpose. Separate sheets should also be made across semesters, even for the same students in the same course. Sheet differentiation can be accomplished in many ways (e.g., by changing alternating row colors or colors of headers).
- **Backup creation.** Always create a backup of your DDHS if possible, for both recovery and template-making purposes. Printing all CMCAS sheets may be considered a form of backup, which can help mitigate disaster (see Warren, 2016).
- **Stay dynamic.** Remember that a CMCAS should be adaptable. Periodic updates and adjustments, such as adding or removing features, will help in creating a customized gradebook that functions as intended.

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Short biographical sketch: Dr. Brian G. Rubrecht is a Professor in the English Department in the School of Commerce at Meiji University, Tokyo, Japan. He has degrees in TESOL and Bilingual Education (Georgetown University, 2000) and Foreign Language Education (The University of Texas at Austin, 2004). He has delivered over fifty presentations at conferences worldwide and has had the honor of serving as a conference keynote speaker. His work spans more than five dozen publications, which include both book chapters and journal articles. His research interests range from language learning motivation and pronunciation to language use in the classroom and pedagogical practices that influence the teaching and learning of other languages. He is currently exploring practical solutions to better prepare his students for life in our increasingly digital world.

1. Vegel (2022) notes experiencing this several times; the author of the current chapter has as well, hence the reason for exploring the subject of electronic gradebooks.
2. This does not preclude such information from being shared via other means.
3. In Microsoft Excel parlance, it is a workbook featuring multiple worksheets.
4. As explained by McKenna (2016), such “open gradebooks” have their own drawbacks.
5. The convenience of having a printed attendance sheet becomes immediately apparent as soon as tardy students make their way to the classroom one by one, thereby intermittently bringing the lesson to a halt, as the computer application currently in use must be switched to the CMCAS to digitally input figures to reflect this SD.

Chapter # 5

ENHANCED CONCEPTUALIZATION OF LEARNING ALGEBRA THROUGH SCIENTIFIC-ORIENTED TEACHING

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ABSTRACT

The purpose of this project is to analyze how the scientific concept of inverse operations can be used as a “bottom-up” approach for teaching mathematical operations with whole and rational numbers. The primary aim of the study is to provide support for teachers in the teaching of scientific mathematical concepts to students of algebra. The theoretical approaches applied in this project are the theories of mathematical structures, especially the theory of inverse semigroups (Abelian groups), and relational thinking, in a comparison with instrumental thinking. The methodological approach uses Vygotsky’s doctrine of scientific concepts. The presentation of the analytical findings expands on previous research on additive and multiplicative inverses in teaching and conceptual learning of algebra. The findings illustrate how connections to mathematical structures and scientific concepts, such as the concept of inverse, lead to an understanding of algebraic operation rules for whole and rational numbers.

Keywords: inverse operations, teaching and learning algebra, conceptual understanding, operations with negative and rational numbers, conceptual meaning and algebraic rules.

1. INTRODUCTION

International research on teaching and learning mathematics is continuously evolving. The reconstruction and development of school curricula and international discourse on mathematics education require teachers to constantly evaluate their view of teaching and choice of mathematical content to support students' sustainable learning. The latest psychological research highlights the importance of conceptual learning in order to situate meaning sense for the conceptual understanding of mathematical concepts, formulas, and methods (Schwartz & Martin, 2004; Hall, Wieckert, & Wright, 2008). This basically means that students form an understanding of mathematics in relation to the invisible mathematical context behind concepts, formulas, and methods, which helps them reconstruct and reproduce mathematical knowledge and skills. The crucial component of conceptual mathematics learning is the link between students' learning and scientific concepts in a “bottom-up” didactic teaching approach that should lead to individual conceptual growth in the students' progress in relation to mathematical premises (Vygotsky, 1986). Conceptual learning also provides a deeper understanding of mathematical procedures, as well as the significance of concepts and formulas.

Researchers agree that the quality of teaching and learning of mathematics depends on the teacher's ability to teach the subject, which plays a central role in their students' ability to acquire mathematical skills. The findings of international empirical and theoretical studies imply that teachers' knowledge of mathematics and their current

teaching strategies do not provide sufficient support for their students' development in the subject (Ball, Hill, & Bass, 2005). What kind of teaching content can provide the optimal interplay between a student's cognitive ability to learn mathematics and their conceptual development in the subject? How should mathematical content be structured to ensure that students understand core mathematical concepts and methods? International research currently has a limited capacity to address such these questions.

According to Vygotsky (1986): "The only good kind of instruction is that which marches ahead of development and leads it" (p. 188). A key to teachers' acquisition of mathematical knowledge for teaching is that they understand the basic ideas of mathematics and didactic tools for teaching.

2. BACKGROUND ALGEBRA AND CONCEPTUAL UNDERSTANDING

Researchers agree that teaching basic algebra such as whole and rational numbers is no easy task because it requires theoretical knowledge. It demands theoretical knowledge about the content. According to Kieran (2004), building of mathematical structures and understanding of number sense in arithmetic creates a conceptual bridge to algebra and other areas of mathematics. Knowledge of number theory and mathematical operations is key to ensuring continuity in the learning of algebra (Kozulin, Gindis, Ageyev, & Miller, 2003). From this point of view, a teacher needs a good overview of (and good insight into) the relevant content in operations, as well as opportunities to identify the multifaceted perceptions of the operations and the logical continuity of algebraic thinking. At the same time, it is important to understand "bottom up" and "breaking down" didactic approaches in the teaching of algebra, as well as the nature of school algebra in relation to mathematics as a science.

The conceptual transition and continuity in students' learning of algebra has been analytically described by Kaput (2008) and in relation to students' learning of rational numbers and their operations in a study by Karlsson and Kilborn (2024a). Researchers agree that teaching algebra effectively is a difficult process and impossible to carry out with only procedural knowledge. More specifically, the generalization of algebra cannot take place without the conceptual generalization of both algebraic concepts and number concepts, including whole numbers, rational numbers, and algebraic operations. At the same time, researchers emphasize that students have difficulties mastering algebraic concepts and the concept of rational numbers (fractions) (Alajmi, 2012; Lee, Choy, & Mizzi, 2021; Berggren, 2022).

It is important that as early as the first school year, students understand that all arithmetic rules are based on algebra. Hence, the best way to teach algebra is to introduce students to the laws of arithmetic from grade 1. At this grade 1, it is also important for students to become familiar with the relationship between the properties of numbers and operations (Karlsson & Kilborn, 2015). One example is the relationship between addition and subtraction (e.g., $7 - 4 = x \Leftrightarrow 4 + x = 7$), which leads students to a conceptual understanding of the subtraction operation "take away". Another example is that $7 - (-5)$ can be illustrated on the number line as the distance from (-5) to 7 , that is, the number 12 (12 steps between two numbers). The understanding of inverse as an algebraic concept is key to students' learning of addition and inverse subtraction of whole numbers, multiplication, and inverse division of rational numbers (Karlsson & Kilborn, 2024b). In more general terms, the concept of inverse plays an important role in students' learning of content such as the square of a number (and its inverse, the square root) and the exponential function (and its inverse, the logarithmic function). Students already know

everyday inverses like “heads and tails” or “passed and failed,” and false inverses like day and night or clever and stupid. In fact, the concept of inverse should be successively introduced and actively used in teaching from primary to lower and upper secondary school in order for students to learn mathematical ideas and their implications in the form of the conceptual contexts of rules and formulas.

In line with this, research should be expanded to address the question of students’ conceptual learning of algebraic concepts through the teaching of fundamental algebra in combination with didactic methods for teaching algebra. This chapter introduces the analytical findings from our research, which illustrate a beneficial approach to mathematical structures, such as the relation between the scientific concept of inverse and the teaching and learning of the conceptual meaning of operations of whole (negative) numbers and rational numbers.

The purpose of this study is to analyze how the algebraic concepts of additive and multiplicative inverse operations can be used as a “bottom-up” approach for teaching algebraic operations with whole and rational numbers. The primary aim of this analytical research is to provide support for the teaching of algebra in primary and secondary school, with a focus on students’ conceptual learning of algebra. This research builds on previous research on additive and multiplicative inverses in teaching and learning arithmetic and algebra (Karlsson & Kilborn, 2023; 2024b) and enhances algebra instruction.

3. THEORETICAL PERSPECTIVES ON MATHEMATICAL STRUCTURE AND MATHEMATICAL THINKING

Mathematical structures are crucial to students’ knowledge of mathematics and teachers’ ability to teach the subject. In this context, mathematical structures stimulate deeper mathematical thinking and help students to engage in the learning process more effectively (Mason, Stephens, & Watson, 2009). The analysis of mathematical structures can also elucidate the connection between “conceptual and procedural approaches to teaching and learning mathematics” (p. 10). In line with this, it is relevant to express ideas about mathematical structures related to teachers’ didactic knowledge of mathematics and how this knowledge can support their students’ learning. According to Mason et al. (2009), a mathematical structure is defined through “the identification of general properties which are instantiated in particular situations as relationships between elements” (p. 10). This underlines two important aspects of the definition of a mathematical structure. The first has to do with the mathematical meaning of general/essential properties, and the second with the “association” between elements. These elements are mathematical objects or concepts, for example, number concepts, algebraic concepts, and related operations. In this context, the operations are related within elements of natural numbers, whole numbers, and rational numbers. In a conceptual sense, the relationship between elements is a connection between these number concepts and the operations that include them, as well as an extension of these operations to algebraic elements/concepts. Understanding mathematical structures as relationships between essential properties within a mathematical structure (mathematical concept), the relationship between different elements and “mastering procedures” facilitates the development of contextual and conceptual meaning in an individual’s mathematical knowledge. The understanding of mathematical structure can result in more effective learning focused on the re-construction and extension of existing mathematical knowledge and the construction of new mathematical knowledge (Mason et al., 2009).

The theoretical issues surrounding mathematical structure clearly indicate which kind of mathematical knowledge makes sense in teaching and learning. In general terms, “making sense” means understanding mathematical structures and the relationships between them in an algebraic context (Kieran, Pang, Schifter, & Fong, 2016). Discussions about mathematical structures in instruction lead to theoretical considerations about the phenomenon of mathematical (algebraic) thinking and contextual sense. Mathematical thinking is important for learners’ analysis of mathematical (algebraic) structures in order to understand content and apply this knowledge to conceptual and procedural learning. Researchers have used a framework for mathematical thinking related to domains such as relational thinking (Skemp, 1976; Starr, Vendetti, & Bunge, 2018) and instrumental thinking (Mason et al., 2009). Skemp (1976) describes the distinction between two different types of understanding (thinking) as relational understanding and instrumental understanding. He defines the concept of understanding as “knowing both what to do and why” (p. 2). Relational thinking/understanding encompasses such issues as what to do and why. Answering the above requires the ability to generalize mathematical structures/concepts according to their essential properties and to make conceptual and procedural connections with other mathematical structures/concepts. Relational thinking includes understanding the properties of numbers, mathematical operations with numbers, and properties for inverse operations, as well as the ability to handle number sentences. In terms of pre-service learning for the teaching of relational thinking, it is important to support the conceptualization of mathematical operations, restructure operations related to transition from one number range to another, as well as teach students the skills they need to generalize mathematical operations from the use of natural numbers and rational numbers to algebraic symbols (Molina & Mason, 2009).

Definitions of Abelian groups have been described by van der Waerden (1971). Mathematical structures, such as the Abelian groups for addition and multiplication for the teaching and learning of algebra in terms of fraction ideas, have been described in previous research (Karlsson & Kilborn, 2024a; 2024b). Mathematical structures refer to students’ ability to develop essential skills in algebra, understanding of the relationships between natural numbers and rational numbers, as well as algebraic rules for addition, including the concept of additive and multiplicative inverse operations. With regard to teaching algebra, research also highlights the importance of Abelian groups as a specific form of mathematical knowledge for effective instruction and the development of conceptual knowledge. According to these researchers (Karlsson & Kilborn, 2023), algebra is a difficult subject to teach and learn. Further, it is also difficult to generalize algebraic concepts. Hence, it is important to investigate how students develop an understanding of general algebraic concepts from a scientific perspective.

4. METHODOLOGY

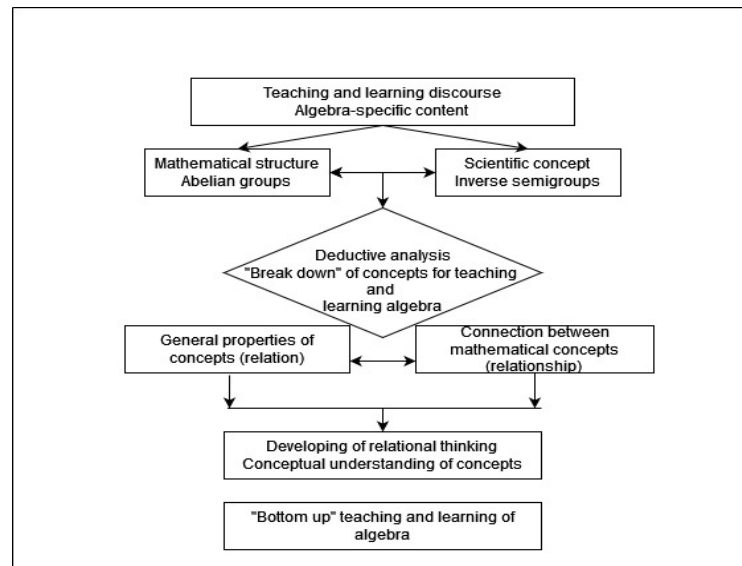
The methodology of this study is rooted in socio-constructivism. This methodological approach uses Vygotsky’s doctrine of scientific concepts (Karpov, 2003). According to Vygotsky’s doctrine, mathematics and algebra are learned in two ways: (1) The first way is when students use “spontaneous” concepts related to the conceptualization and generalization of everyday experiences and knowledge. (2) The second way is grounded in “scientific” concepts and students’ learning of mathematics (algebra) through the generalization and the systematic accumulation of human scientific knowledge, which is closely related to mathematical nature, ideas, and the historical development of mathematics as a science with a focus on what lies behind different formulas, concepts, and

methods. These two kinds of knowledge create the conditions and opportunities for conceptual learning and mathematical reasoning and thinking. It is crucial to understand that spontaneous concepts are prerequisites for the construction of scientific concepts.

4.1. Scientific Knowledge and Concepts

A closer investigation of what students should learn (learning outcomes) turns the lens on classroom instruction and how content should be taught in relation to student learning. In the context of scientific knowledge and theoretical views on scientific (theoretical) knowledge and its significance for mathematics learning in the conceptual sense (Karpov, 2003), this study relies on the core theories of socio-constructivism, specifically the crucial role of theoretical thinking and learning. In this approach, theoretical thinking is applied in the investigation of abstract mathematics as a school subject. The application of theoretical perspectives to mathematical structures is key to the development of mathematical thinking in teachers, as well as for their understanding of the same process among their students. It is also crucial to emphasize that theoretical-analytical learning effectively maximizes the opportunities for abstract thinking and the generalization of content and concepts. The question of how teaching content can be broken down into logical sequences that learners can adapt and absorb is a key aspect of mathematical knowledge for teaching. Against this background, and in terms of the mathematical preparation of teaching for teachers, content knowledge should be theorized in a manner that underscores the clear interplay between theoretical knowledge and its impact on the teaching of mathematics. The theoretical approach of this study focuses on how scientific knowledge and concepts lead to reflections on why theoretical concepts should be taught as a basis for learning of mathematics, specifically algebra (Bakirov & Turgunbaev, 2019). The systematized theoretical framework of the study is presented in Figure 1.

Figure 1.
Systemized theoretical framework: Teaching and learning of algebra.



4.2. Analysis Track

To track the construction of the deductive analysis of the inverse semigroups for the teaching of algebra, we have utilized a conceptual chart of theoretical starting points in combination with a methodology about mathematical structure/scientific concepts in the teaching and learning of mathematics. The methodology of this study is also grounded in a systematic analysis of the essential properties of the concept of inverse. The analytical construction of the teaching and learning discourse, as well as the findings related to the teaching of algebra with a focus on whole numbers, rational numbers, and algebraic operations, is deeply grounded in the researcher's awareness and understanding of the school's mathematics-algebra discourse.

5. RESEARCH FINDINGS, SCIENTIFIC CONCEPT, AND TEACHING

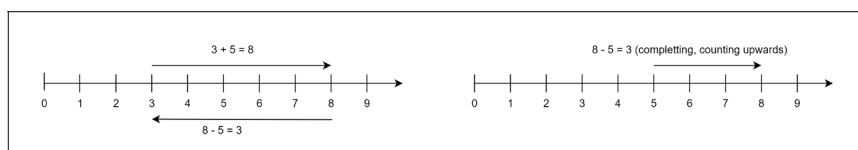
The findings of the study are presented with a focus on the relational and conceptual components of additive and multiplicative inverse concerning the teaching of whole and rational numbers and operations with these numbers.

5.1. Finding 1. Addition of Whole Numbers and their Inverse, Subtraction

The additive inverse (van der Waerden, 1971) can be illustrated by the natural number 5 and its additive inverse (-5) as a negative number, where the sum of the numbers 5 and (-5) is zero. On the number line, this can be expressed as being mirrored around the neutral element 0. This illustrates how negative numbers are inverses of their positive, natural counterparts.

On the number line, adding 5 can be expressed as an arrow five units in length, pointing to the right; subtracting 5 can be expressed as an arrow five units in length pointing to the left. The addition equation $3 + 5 = 8$ and the subtraction equation $8 - 5 = 3$ are illustrated on the number line in Figure 2.

Figure 2.
Addition and inverse operation subtraction.



The subtraction equation $8 - 5 = x$ can also be carried out as the inverse of the open addition equation $5 + x = 8$ by *completing on the number line*, that is, counting up from 5 to 8 in 3 steps. This is shown on the number line in Figure 2 (counting upwards). If the rule regarding the sum of two whole numbers is applied ($b + (-b) = 0$), it is easy to understand how to carry out the subtraction equation $a - (-b)$. We start by subtracting $a - b$ and then add $(b + (-b))$. By using the commutative law of addition, we find that $a - b = a + (-b)$. This means that $a - b = a +$ (the inverse of b). However, as this is true for all whole numbers, it also means that $a - (-b)$ equals $a +$ (the inverse of $(-b)$) $= a + b$. The relational thinking about the addition of whole numbers and their inverse, subtraction can be extended to rational numbers. The overall conceptual goal is for students to understand basic algebra to explain the following operations, as well as to build an understanding of the essential

properties of whole numbers in order to understand algebraic concepts and methods. These are given by the Abelian semigroup for addition, where:

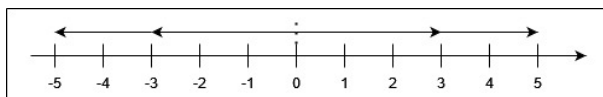
1. the same arithmetic laws apply to whole numbers as to natural numbers.
2. *negative numbers* are inverses of those natural numbers.
3. subtraction is the inverse operation of addition which leads to $a - b = a + (-b)$ or at a deeper level, $a - (-b) = a + (\text{the inverse of } (-b)) = a + b$.
4. in order to be able to follow algebraic reasoning, for example, $a + (-b) = a + (b - b) + (-b) = a - b + b + (-b) = a - b$.

5.2. Finding 2. Negative Numbers and Additive Inverse Operations

Case 1. Addition of negative numbers

Negative numbers can also be broken down into terms. In the same way as $5 = 3 + 2$, the inverse applies as $(-5) = (-3) + (-2)$; see Figure 3.

Figure 3.
Negative numbers as inverses.



Against this background, it is easy to understand the addition of whole numbers, for example:

- (1) $7 + (-3) = 4 + 3 + (-3) = 4$ because $3 + (-3) = 0$, which should be compared to $7 - 3 = 4$; and
- (2) $4 + (-9) = 4 + (-4) + (-5) = (-5)$ since $4 + (-4) = 0$, which should be compared to $4 - 9 = (-5)$.

Case 2. Subtraction of negative numbers

Applying the concept of inverses and the fact that $(b + (-b)) = 0$ leads to $a - b = a + (b + (-b)) - b = a + (-b) + (b - b) = a + (-b)$. This means that $a - b = a + (\text{inverse number of } b) =$ if a and b are whole numbers. As a conceptual consequence of inverse operation, this method enables an understanding of subtraction of negative numbers. For example:

- (1) $6 - 2 = 6 + (\text{the inverse number of } 2) = 6 + (-2)$; and
- (2) $6 - (-2) = 6 + (\text{the inverse number of } (-2)) = 6 + 2$.

The subtraction of negative numbers is confusing for many students. One reason for this is that they often learn algebraic rules by rote, such as “Two equal signs make a plus sign,” although the two signs for “minus” are very different. By learning inverse algebraic operation, it is possible for students to understand the relational and conceptual meanings of algebraic rules.

Case 3. Multiplication with negative number(s)

To examine what it means to multiply two whole numbers, we can start with $a \cdot (-b)$, where $a > 0$. We then apply the distributive law: $a \cdot b + a \cdot (-b) = a \cdot (b + (-b)) = 0$. This means that $a \cdot b$ and $a \cdot (-b)$ are inverse numbers and, consequently, that $a \cdot (-b) = (-a \cdot b)$ the same way that $(-a) \cdot b = (-a \cdot b)$.

How do we interpret the multiplication $(-a) \cdot (-b)$ of two negative numbers? By once again using the distributive law, we find that $(-a) \cdot b + (-a) \cdot (-b) = (-a) \cdot (b + (-b)) = 0$, which means that $(-a) \cdot (-b)$ is the inverse of $(-a) \cdot b$, whose inverse is $a \cdot b$. Consequently, $(-a) \cdot (-b) = ab$. In sum, the finding is that the product of two negative numbers is a positive number. By understanding multiplicative inverse, it is possible for students to understand the relational and conceptual meanings of algebraic rules with a focus on the multiplication of negative numbers.

5.3. Finding 5. Rational Numbers and Inverse Operations

Concerning multiplication, for every a in the group (provided that $a \neq 0$), there is an element $\frac{1}{a}$, such that $a \cdot \frac{1}{a} = 1$. In this case, $\frac{1}{a}$ is the (multiplicative) inverse of a and vice versa (van der Waerden, 1971).

Case 1. Multiplication of rational numbers

The analytical findings of inverse are related to *the multiplication of two rational numbers*. To begin with, let us multiply two basic fractions, $\frac{1}{a}$ and $\frac{1}{b}$, and then multiply their product by $(a \cdot b)$. We then apply the commutative and associative laws:

$a \cdot b \cdot (\frac{1}{a} \cdot \frac{1}{b}) = (a \cdot \frac{1}{a}) \cdot (b \cdot \frac{1}{b}) = 1 \cdot 1 = 1$. Since the product $a \cdot b \cdot (\frac{1}{a} \cdot \frac{1}{b}) = 1$, the inverse of $(\frac{1}{a} \cdot \frac{1}{b})$ is $a \cdot b$. However, the inverse of $a \cdot b$ is $\frac{1}{a \cdot b}$. Consequently, $\frac{1}{a} \cdot \frac{1}{b} = \frac{1}{a \cdot b}$. This means that $\frac{a}{b} \cdot \frac{c}{d} = a \cdot \frac{1}{b} \cdot c \cdot \frac{1}{d} = ac \cdot \frac{1}{bd} = \frac{ac}{bd}$. Consequently, $\frac{a}{b}$ is the inverse of $\frac{b}{a}$. Case 1 illustrates the conceptual meaning of the formula for the multiplication of rational numbers.

Case 2. Division of rational numbers

In case 2, the inverse operation for division is defined in a way that can also be applied to the division of rational numbers. Such a definition is that $a \div b = a \cdot \frac{1}{b}$. This means that the division of two rational numbers can be interpreted as $\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \cdot \frac{d}{c}$ and more explicitly, this means that $\frac{2}{7} \div \frac{1}{3} = \frac{2}{7} \cdot \text{inv}(\frac{1}{3}) = \frac{2}{7} \cdot 3 = \frac{6}{7}$ and $\frac{2}{5} \div \frac{3}{7} = \frac{2}{5} \cdot \frac{7}{3}$. Against this background, students with only a basic understanding of algebra can conceptually understand the formula for *the division of two fractions*.

In order to carry out division where $\frac{a}{b} / \frac{c}{d}$, the concept of inverse is used. Since $\frac{c}{a} \cdot \frac{d}{c} = 1$, then $\frac{d}{c}$ is the inverse of $\frac{c}{a}$. The definition of $\frac{a}{b}$ is $a \cdot (\text{inverse of } b)$. This logically leads to $\frac{a}{b} / \frac{c}{d} = \frac{a}{b} \cdot (\text{inverse of } \frac{c}{d}) = \frac{a}{b} \cdot \frac{d}{c} = \frac{a \cdot d}{b \cdot c}$. This is a conceptual explanation of the formula for the division of rational numbers.

This is an interesting point for relational thinking. Since $\frac{a}{2} \div \frac{a}{2} = 1$ and $\frac{2}{a} \cdot \frac{a}{2} = 1$ independent of a , everything depends on the conceptual meaning of the division formula as a result of an inverse operation multiplication.

6. FUTURE RESEARCH DIRECTIONS

Future research directions could be to develop more effective instructions with a focus on mathematical structures and scientific concepts, as well as the impact on students' conceptual learning. It is also important to investigate the conceptual potential of Abelian groups and the implementation of the concept in school algebra in a structured and logical manner. An important future research direction is to conduct empirical studies that investigate teacher educators' practices in algebra-oriented learning, as well as to incorporate the theoretical findings of the present study, namely, the teaching model for negative and rational numbers as a means to enhance students' understanding and the effectiveness of mathematics education.

7. DISCUSSION AND CONCLUSION

This study analyses how the algebraic concept of additive and multiplicative inverse operations can be used as a “bottom-up” approach for teaching mathematical operations with whole and rational numbers. The findings show that mathematical structures and the concept of inverse operations of rational numbers can provide teachers with systematic conceptual support when planning instruction. This can help them teach algebra effectively, specifically whole and rational numbers and operations that include these numbers, in order to develop their students' relational thinking and understanding of algebraic rules and formulas (Skemp, 1976). At the same time, the theoretical framework of this research (Figure 1) can provide teachers with a clearer understanding of the methods of working from the “bottom up” and “breaking mathematical concepts down” as two different approaches (inductive and deductive) for teaching and learning. The analytical findings show a clear connection to how the mathematical structures/scientific concepts of inverse operations for addition and multiplication can be implemented and handled to promote the conceptual understanding of algebra, while employing teaching-based practice. This suggests that all students should master operations with negative and rational numbers instead of focusing on the rote memorization of rules and formulas. However, the ability to make decisions about teaching quality and approaches to the teaching and learning of algebra depend on the teaching content and interplay between teaching content and intended learning outcomes (Molina & Mason, 2009; Kieran et al., 2016; Karlsson & Kilborn, 2023; 2024a; 2024b).

These analytical results can enhance the ability of teachers' and students to grasp these mathematical operations and inform the approaches used in the teaching and learning of such operations. This study also illustrates how mathematical structures and scientific concepts can be implemented in school mathematics for teaching and learning purposes. The implementation of innovative teaching approaches linked to a deeper scientific understanding can provide a conceptual device and the ability to grasp the meaning of algebraic concepts that students have not yet mastered, concepts that are important for sensemaking in their learning.

The analytical results of the study provide analytical frameworks for subsequent empirical studies with a focus on teaching and students' learning of algebra. The results also contribute to the effectiveness of mathematics teaching and learning in the conceptual sense and provide new knowledge on approaches to the teaching and learning of mathematical structures and scientific concepts.

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Chapter # 6

TEACHERS' VIEWS ON INFUSING INDIGENOUS KNOWLEDGE INTO CHEMISTRY TEACHING AT THE JUNIOR SECONDARY OF OMUSATI REGION

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ABSTRACT

This study focused on the views of Natural Sciences teachers in infusing indigenous knowledge (IK) in teaching of Chemistry concepts at the junior secondary school. IK remains an afterthought in many Omusati region classrooms especially at grades 8 and 9 level. This is despite the National Curriculum for Basic Education promoting the inclusion of indigenous knowledge into teaching to empower learners to actively participate in making Namibia a knowledgeable-based society. Five grades 8 and 9 Physical Sciences teachers were purposefully selected from one circuit in the Directorate of Education, Arts and Culture of Omusati region, Namibia. Researchers employed an interpretivist qualitative research approach. This qualitative study used CHAT to understand the teachers' views and classroom practices through integrating IK in teaching of Chemistry. Saldana (2013) was used to guide thematic analysis of data. The findings indicated a slight change of views by the Physical Science teachers. Some remained attached to certain practices where they held strong beliefs. The infusion of certain Chemistry concepts depended on the school support. The study recommended that teaching and learning policies be clear on the 'how' of infusing IK into the classroom, and adequate support through ongoing developmental workshops be provided to the Science teachers.

Keywords: physical science teachers, views, indigenous knowledge, chemistry concepts, continuous professional development (CPD).

1. INTRODUCTION AND PROBLEM

This chapter focuses on Natural sciences teachers' views in the infusion of indigenous knowledge (IK) into Chemistry teaching. IK is "considered an entry point in incorporating knowledge and its relevance into the abstract world of science" (Sotero, Alves, Arandas, & Medeiros, 2020, p. 18). This statement underscores the importance of linking science with learners' daily experiences at their environment where they generate knowledge through the engagement with community members and their socio-cultural practices in eventually making meaningful learning experiences. Mandikonza (2019, p. 2) concurs that "learners bring tacit as well as explicit and conceptual knowledge into learning contexts." He (Mandikoza, 2019, p. 2) also notes that due to lack of recognition and infusion of IK in the classrooms, "learners from rural and disadvantaged communities tend to find a poor fit between their home experiences and what they learn at school." Moreover, science teachers at junior secondary level still believe that learners enter science classrooms as tabula rasa, and disregards whatever knowledge learners have (Buma, 2018; De Beer, 2016). As part of colonised generation, teachers find it difficult to relate IK to science during teaching in a

meaningful way, they instead overlook IK related concepts (Yeseraw, Melesse, & Kelkay, 2023). Generally, the world over, indigenous knowledge is considered less important, particularly in the science classrooms. Mukwambo (2017) in Zambezi region of Namibia found that learners' cultural practices were distanced from their science practices in schools, as such many find science to be out of this world and difficult to learn. Though many African countries still believe strongly in the western worldview that marginalises the indigenous culture and practices, new curriculum reforms such as CAPS for South Africa and NCBE for Namibia advocate for the integration of indigenous knowledge in teaching, particularly science (De Beer, 2016). The intention being to contextualise science methods and optimize on promoting local productions for self-sustenance (Nwokocha & Legg-Jack, 2024). The integration of indigenous knowledge is a complex multifaceted issue that demands attention and action from educators and researchers (Andrew, Girma, Gabriel, & Petros, 2023). However, Mavuru and Makhunga (2020) found that there has been no concerted effort in assisting teachers to identify relevant teaching strategies to infuse indigenous knowledge into science concepts. The uncertainties around the 'how' of infusing IK remain a hurdle for many teachers. This study found it necessary to tap into teachers' space and solicit their views on infusing IK into Chemistry teaching and learning, particularly the distillation concept. The following question guided data collection for this paper: *What views do Physical Science teachers have with regards to infusing indigenous knowledge into Chemistry teaching?*

2. THE PURPOSE OF THE STUDY

The purpose of this study was to solicit teachers' views on infusing IK in the teaching and learning of Chemistry concepts. A four-week intervention based PDI on indigenous knowledge integration in the teaching of Chemistry concepts by junior secondary schools Physical Science teachers was ran to provide guidance. The world over, IK has been alienated from school curricula for a long time (Aikenhead, 2000; Ogunniyi, 2007; Gundry & Cameron, 2008; Battiste, 2018). It is seen as odd and limited in the eyes of Western science. According to Aikenhead (2020), Western science that is taught in schools is a subculture of Western culture and their worldviews that seldom forget social activity in real life environment. This creates problems on the imbalances in societies where cultural values and local wisdom are marginalised (Handayani, Wilujeng, & Prasetyo, 2018). Additionally, Cronje (2015) argues that majority of learners in South Africa come from indigenous background, but the science they are taught in schools is informed by Western culture, using Western teaching strategies. Similarly, Namibia as a developing country, has many learners who hail from indigenous background but their teachers who were trained through a western science curriculum have a similar problem in their teaching. This makes the learning of Chemistry abstract; hence the need to find out from teachers how they deal with the infusion of IK in their classrooms?

3. RESEARCH DESIGN

The study utilised interpretive qualitative case study research design. This is a single case study in which the schools involved are from one regional directorate of Education, Omusati region, in Namibia. They are all rural schools from the same geographical area and share similar characteristics of being located in previously disadvantaged communities. Teachers who participated used the same syllabus, resources and circuit-based tests and

examinations. Additionally, the learners are non-borders, and they commute every day to and from schools. Therefore, all schools represent one phenomenon and only one unit of analysis is used. This paper reports on the 5 grades 8 and 9 purposively selected Physical Science teachers to investigate multiplicity of perspectives (Ritchie & Lewis, 2003) of the phenomenon within its real-life context (Yin, 2003). This assisted to gather different views from diverse backgrounds and experiences of the research participants. Moreover, using case study design assisted to gain in-depth insight of this case's current issues within its real-life setting.

4. METHOD

4.1. Data Collection Instruments

Data were collected through open-ended questionnaires, one-on-one interviews, lesson observations, and document analysis. Instruments used included VNOIK and SDLI questionnaires, interview protocols, and observation schedules.

The instrument (VNOIK) was adopted from Cronje, De Beer, and Ankiewicz (2015) developed to determine the views of science teachers on Indigenous Knowledge in South Africa. It consists of ten open-ended questions regarding teachers' opinions about the nature of indigenous knowledge. The other instrument (SDLI) was adapted from Cheng Kuo, Lin, & Lee-Hsieh (2010). This instrument was used to measure the self-directed ability of Grade 8-9 Physical Science teachers in integrating IK when teaching Chemistry. It measures perceptions of self-directed learning in four domains of learning motivation (LM), planning and implementing (PI), self-monitoring (SM) and interpersonal communication (IC). The two instruments were administered pre- and post-intervention to solicit the teachers' views of infusing IK into Chemistry concepts teaching. It is worth mentioning that adapting this instrument could not compromise the reliability and validity of the instrument (Daunert & Seel, 2020). The adaptation of the instrument involved slight modification of terms to contextualize it to suit the Namibian participants. Otherwise, all factors were identical to the original SDLI. For the lesson observation, the Reformed Teaching Observation Protocol (RTOP) (Sawada, Piburn, & Judson, 2002) was adopted for data collection. This instrument was developed to provide a standardized means for detecting the degree to which classroom instruction in mathematics or science is reformed (Piburn & Sawada, 2000; Sawada et. al., 2002). For this study, the 25 aspects of this instrument were grouped into main five categories namely, lesson design and implementation, content- propositional pedagogic knowledge, content- procedural pedagogic, classroom culture - communicative interaction and learners-teacher relationship; helped to evaluate classroom instruction and teaching approach. It provided insight into whether the five (5) teachers observed created an atmosphere that is conducive for SDL and elicitation of indigenous knowledge to enhance learning of Chemistry concepts. It also assisted in observing other teaching and learning activities that might arise in line with the study's interest during the lesson observation. Like the questionnaires, these two instruments were also administered pre and post intervention.

4.2. Data Collection Procedure

The 5 purposively selected teachers individually completed the two open-ended questionnaires (VNOIK and SDLI) before and after intervention in a common location. No one influenced the other, as everyone answered and expressed themselves from their own knowledge and experience.

4.3. Presentation of the Results

The Code-to-Theory model of thematic analysis by Saldana (2013) as an analytical tool guided the identification patterns of meaning across dataset. It became essential for describing and interpreting the meaning and importance of the emerging themes in different ways. Since this tool is not tied to any specific ontological and epistemological anchors (Braun & Clarke, 2006) it allowed for flexibility in reporting participants' ideas, meanings and experiences. Data coding and categorization gave 67 codes and 11 categories. Though six themes emerged from the 11 categories, the results reported for this paper focused only on the two themes that were directly related to the teachers' views. The two themes reported on are: (i) Myth of IK as non-scientific and (ii) Subjectivity of human enterprise as influenced largely by indigenous knowledge system.

4.3.1. Theme I): Myth of IK as Non-Scientific

The theme - myth of IK as being non-scientific is operationalised as including rituals, beliefs and spiritual elements of IK and are seen as non-scientific. It emerged as science teachers engaged each other in speaking out their individual ideas about IK as inherited from ancestors.

Pre-intervention when completing the VNOIK instrument, teacher 5 mentioned something about the 'healing' of lightning when it strikes either a house, a tree or animals. She said *"....adults will call a healer who is in touch with ancestors to cure lightning by removing its urine (Omasita)...the meat of an animal struck by lightning cannot be eaten before it is treated."* 'Urine of lightning' is given this name from the waste product of animal excretion. She further said, *it is believed that animals always urinate where others urinated before, as such the waste product of the previous lightning may attract the next lightning, so that spot is believed to still have power to attract other charged materials (lightning), causing danger to the surroundings.* This phenomenon refers to properties of a charged object in Physical Science Grade 8 syllabus.

During pre-intervention interviews, not much was shared in terms of myths. However, whilst on the lightning issue, during the intervention, the discussion got heated. Teachers 4 and 3 also highlighted some of myths about lightning. Teacher 4 said *"...during thunder and lightning, an adult tells children not to be close to animals, not to put on red-coloured clothes and not to shelter under trees."* These myths are said to prevent children from being struck by lightning, he further added. However, the admonition to children not to shelter under the trees when it is raining is connected to the scientific knowledge that lightning strikes the tallest point, and trees in most cases are taller than any construction in rural areas. Teacher 3 added *"...Traditionally, people used traditional earth wire, such as dry branch of Omulavi tree placed on the high point of traditional hut."* He further explained that this tree has unique properties of electric induction, thus protecting against lightning striking huts where people live. Though not tested, Omulavi tree might have negative charges that are capable of repelling and diverting or distributing electric charges of lightning.

Although the discussions during the intervention pointed to some myths being scientifically aligned as in the responses above, and the fact that they promote certain good practices such as hygiene, for an example the indictment not to urinate in any pond of water as this makes one a victim of snakebites, promotes hygiene among young children. Many participants expressed understanding myths as rumours spread by elders, other participants expressed their concerns that some myths hinder the integration of IK into teaching. Teacher 2 said *"....some of the traditional ways of doing things are associated with magic, sorcery and witchcraft."* He further indicated that young people do not want to inherit such wisdom due to the negative labelling attached to the practices. Teacher 1 concurred in

most cases as common practices from her culture and space. Post intervention, all the participants retained their stance on the myths.

This study found that although myths cannot be scientifically proven due to lack of empirical evidence, myths are important in society as they can prevent certain ills. Apart from keeping order, myths emanate from events and activities experienced before. However, during the intervention participants expressed their opinion that indigenous knowledge and practices (including myth) are valuable sources of scientific knowledge. They believed that western scientists stole or plagiarized the IK and modified these in order to fit their situation, hence no new knowledge was generated.

4.3.2. Theme II): Subjectivity of Human Enterprise as Influenced Largely by Indigenous Knowledge System

This theme is operationalised in this study as personal opinions on how Physical Science teachers construct and express their sense of self-identity values and emotions in relation to the social and material context they live in. The VNOIK questionnaire confirmed that most of the participants believe that indigenous knowledge can alleviate some Sustainable Development Goals (SDG) related to problems such as hunger, poverty and underdevelopment. For instance, in pre-intervention VNOIK, teacher 5 responded to How their own views of self-directed learning influence their subjectivity to human enterprise: *"...nowadays we depend too much on western way of life which is very expensive in terms of livelihoods. Only if we can reverse and follow the traditional way of living like our forefathers who depended on their natural environment only...only if we can gather food and medicine from our natural environment as it was done before"*. In support, Teacher 1 added that *"alternative to western ways of living is the indigenous way of life. There are plenty of indigenous foods such as palm fruit and forest food.... carving and making traditional artefacts such as omatiti and uuholo (traditional plates and cups made from roots of the omukanga tree). They can be used at home instead of modern cups/glasses and plates. Traditional neckless (made from small round pieces of snail shells) be used by woman and girls for decoration."* This was indicative of how much the participants still value their artefacts and IK life. This increases confidence and respect within a given community. This was evidence of an element of SDL in science teachers. Similar findings emerged post-intervention VNOIK. For example, when VNOIK questionnaire sought participants' views on whether IK can alleviate some problems, Teacher 2 answered *"...yes, because in harmonising it with western knowledge, it helps to address challenges such as climate change and sustainable agriculture to new pathway for sustainable development for ensuring livelihood of indigenous and local communities."* Teacher 5 concurred *"...indigenous people need to be encouraged to sustainably use their natural resources available in their environment or the knowledge they inherited from their forefathers to eradicate poverty and hunger. Traditional way of life is cheaper compared to western way of life."* They all agreed that IK way of life has the capacity to improve the environment for the communities in term of survival, agriculture, and medicine. Teacher 1 also highlighted on one of the traditional practices of IK artefacts, pottery making (ceramics) by girls and women only. This practice allowed girls to learn and interact with IK artefacts. It was to the advantage of schoolgirls to understand the properties and behaviour of ceramics (as articulated in the syllabus) in schools. However, a concern was raised during the intervention that the traditional practice of pottery is slowly diminishing due to modern technology and fast adaption of western culture within communities.

Of the five participants of this study, not all advocated for the incorporation of IK into teaching Chemistry concepts due to the absence of scientific terminology. However, they all felt that local and indigenous knowledge is essential and should be encouraged and included into human enterprise activities such as collaboration with pharmaceutical companies. Through post-interviews, participants indicated the need to incorporate IK and its practices into essential discussions such as climate change, adaptations and sustainable development. The use of vernaculars (code-switching) in class pre- and post-intervention in explaining indigenous knowledge in line with scientific knowledge made learning live, participatory and active. This was seen as educating the community, which can enhance in the integration and transmission of IK to complement the mainstream education system.

4.4. Ethical Considerations

In conducting this study, the researchers endeavoured to “foreground dignity, respect, trust and welfare of the respondents that were involved as well as honesty with other professional colleagues” (Leedy & Ormrod, 2010, p. 101). Ethical clearance was obtained from NWU-EMELTEN-REC (NWU 01057-21-A2). Formal permission request letters were then sent to the gatekeepers such as school principals and school governing bodies (SGBs), Acting-inspector of education responsible for Onesi circuit and to the Omusati Regional Director of Education, Arts and Culture (Office of the Director) requesting their consent to conduct the research in the specified region.

5. DISCUSSION OF FINDINGS

Pre-intervention VNOIK and interview there was limited knowledge in terms of myths in IK amongst all the teachers. This was also observed at the beginning of their professional development intervention. During the intervention, teachers discussed and used a variety of IK activities and practices, as they became aware of the myths and whether they are scientific (Busingo, Yadav, Mugisha, & Mashood, 2024).

Post intervention there was knowledge build up and refinement on IK myths and their influences on society particularly the young generation, this showed a deep understanding of some practices and stories they were told when they grew up and how they could now link those with the curriculum as well as how they could make use of that for learners’ prior knowledge. Sebotsa, et al, (2018) found that though teachers value IK, they have under developed knowledge of IK thus their reluctance of infusing it in their teaching. All the five (5) teachers demonstrated how they value IK and its influential practices which are still valid today as a way to sustain one’s livelihood which link to SDG. Like Samuel (2020) and Atanga (2022) findings, post intervention not all teachers could improve instantly post intervention. They need to gradually and consistently practice before they get perfect.

VNOIK and interviews showed that some teachers believe that IK was generated and validated a long time ago through trial and errors method. Other teachers (including Teacher 3) felt that IK can be validated using western knowledge to create a sense of respect. This concurs with De Beer and Van Wyk (2019) who assert that validation of IK by western scientists is empowering and creates respect for the rigour of IK in the broader society. Few participants of this study through interview and intervention showed that some of indigenous knowledge and practices could not be validated but can only be experimentally observed. Though not all-indigenous knowledge practices can be scientifically validated, some practices are directly linked to the scientific concepts such as the use of Omulavi tree with its properties to protect their huts (houses) from lightning.

6. CONCLUSION

Based on the findings, although Physical Science teachers had basic knowledge and views about indigenous knowledge pre-intervention, they could not fully integrate IK into their teaching. This study's limitation was the sample size. Only 5 Physical Sciences teachers were used from the whole circuit of 12 schools, thus the results cannot be generalized. Even though two of 5 struggled to incorporate it into their classroom post intervention, 3 teachers (1, 4, and 5) managed to fulfil the sociocultural aspects of Ministry of Education, Arts and Culture (2015), which encourages the use of cultural and social aspects of learners' environment as meaning-making tools and teaching resources for a knowledge-based society. Based on the results given here, this study opines that the way teachers' attitude towards IK influences their effort to integrate it into their classrooms. Fortunately, post- intervention things were not as severe as pre-intervention. At least 3 of the 5 teachers showed a general improvement in their views of infusing IK into teaching Chemistry. As such, teachers were able to identify appropriate indigenous knowledge and practices that can fit into the teaching of Chemistry concepts. Observations also showed an improved willingness to learn from each other's experience. This indicated a shift in terms of self-directed learning dimension of learning motivation and self-monitoring. Post intervention interviews indicated continuous communication and interaction amongst them community, this implies an urge for continuing professional development need that may see effective implementation of revised curriculum (Ministry of Education, Arts and Culture, 2015). Thus, this study recommends, ongoing professional developments trainings.

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Chapter # 7

COMPARISON OF VISUAL AND PHONOLOGICAL SKILLS IN DYSLLEXIA SUBTYPES: CLINICAL AND EDUCATIONAL IMPACTS

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ABSTRACT

The objectives of this study were to characterize and compare the visual, phonological and mixed subtypes of schoolchildren with an interdisciplinary diagnosis of developmental dyslexia. A total of 122 schoolchildren, aged between 8 years and 11 years and 11 months, from the 3rd to 5th year of Elementary School I in the public network, divided into groups, being GI (61 schoolchildren with an interdisciplinary diagnosis of dyslexia); and GII (61 schoolchildren with good academic performance), paired with GI in relation to the school year. All were submitted to Phonological Skills and Visual Perception Assessments. Factors were created for profile classification for GI, with dyslexics separated into phonological, visual and mixed profiles. The results indicated that there was significance for all comparisons between GI and GII. There was a significant difference between the GV and GPH groups; GPH and GM groups and Between GV and GM. The findings of this study allow us to conclude that schoolchildren with dyslexia can present visual defects regardless of the phonological one. These findings have clinical and educational implications.

Keywords: phonological awareness, visual perception, learning, education, educational measurement.

1. INTRODUCTION

Reading places great emphasis on visual skills and can therefore, improving them, as acquisition of literacy transforms the human brain (Dehaene, Cohen, Morais, & Kolinsky, 2015). Learning to read must be seen as multifaceted, in which visual and phonological skills are united (Woodrome & Johnson, 2009). Reading requires visual perception and discrimination, memory and retrieval of visual sequential aspects and directional orientation (Dehaene et al., 2015; Woodrome & Johnson, 2009). Considering the fundamental role of reading, learning it is necessary as soon as you enter school, in elementary school. To learn to read in an alphabetic writing system, as Brazilian Portuguese language, the child must develop the perception that speech can be represented by graphic symbols, and that graphic symbols represent the sounds of the language (Dehaene et al., 2015; Scliar-Cabral, 2003). This perception develops through constant exposure to the writing system and the efficient teaching of alphabetic principles (Germano & Capellini, 2016; Scliar-Cabral, 2003).

Furthermore, it is necessary that the different brain regions, responsible for processing the skills involved in the acquisition and development of reading, are functioning properly and integrated. (Dehaene et al., 2015; Germano & Capellini, 2016). It also requires intermodal integration, that is, the translation of visual symbols into meaningful auditory equivalents (Birch & Belmont, 1964). In this way, typical readers use visual skills to read familiar words that constitute their visual vocabulary, without having to discriminate

individual letters or component syllables (Myklebust, 1965). In contrast, when there are unknown words, the reader needs to use the auditory pathways, through a process of phonetic and syllabic analysis and synthesis (Chiarenza, Di Pietro, & Casarotto, 2014). Difficulties in any of these aspects of the process of learning to read will lead to the development of poor reading skills and potentially to a reading disorder, such as dyslexia.

Based on these assumptions, Boder (1973) postulated the existence of three subtypes of dyslexia: dysphonetic, dyseidetic and mixed. Readers with dysphonetic or phonological dyslexia have good visual skills and an inability to analyze phonological aspects, as evidenced by the difficulty in associating phoneme-grapheme and consequently fail in phonetic decoding. Readers with dyseidetic or visual dyslexia present good phonological analytical-synthetic skills and difficulties in visual function, referred to as a deficit in visual memory, and in the perception of letters or whole words, with important negative consequences in the development of an adequate internal vocabulary. Readers with mixed dyslexia present a global deficit, including difficulties in organizing visual and auditory perception, resulting in difficulties in the formation of an internal vocabulary and the acquisition of phonetic skills (Boder, 1973; Chiarenza et al., 2014).

Developmental dyslexia is a neuro-cognitive disorder described as a difficulty in acquiring reading skills, despite adequate intelligence and sufficient reading opportunities (Shaywitz, 1996). Reading requires the coordination and integration of visual and verbal information. In particular, children's awareness of the relationship between sounds and letters, or letter-sound correspondence, has been emphasized. Phonological awareness was suggested to underlie grapheme-phoneme conversion (Share, 1995). In contrast, visual perceptual skills, which appear to be essential to letter learning, have been much less thoroughly investigated (Woodrome & Johnson, 2009) especially regarding dyslexia.

Therefore, this study was based on the hypothesis that schoolchildren with dyslexia subtypes would have difficulties with visual and phonological skills.

2. OBJECTIVES

The objective was to characterize and compare visual, phonological and mixed profiles in schoolchildren with an interdisciplinary diagnosis of developmental dyslexia and with good academic performance.

3. METHODS

This study was approved by the Research Ethics Committee of the Faculty of Philosophy and Sciences – CEP/FFC/UNESP, under numbers 3.202.014 and 4.862.668. A total of 122 schoolchildren, aged from 8 years to 11 years and 11 months old (35 women, 43 men, mean age = 25.25, SD = 2.248), from the 3rd to the 5th year of Public Elementary School I, were divided into GI groups composed of 61 schoolchildren with the interdisciplinary diagnosis of dyslexia; and GII composed of 61 schoolchildren with good academic performance, matched with GI in relation to the school year. GI was composed of schoolchildren with the interdisciplinary diagnosis, carried out by the Learning Deviations Laboratory (LIDA/ UNESP – FFC/ Marília – SP), composed of speech therapists, neuropsychologist and occupational therapist, based on the criteria described in the Statistical Manual for Mental Disorders and of Behavior – DSM-V (APA, 2014; Germano, Reilhac, Capellini, & Valdois, 2014). Schoolchildren from GII were indicated by their teachers with good academic performance, with good academic performance being those

who presented satisfactory performance in two consecutive two-month periods in the Portuguese Language and Mathematics assessment, with a grade greater than or equal to the average (5.0). Schoolchildren from GII were paired with GI and their profiles, according to chronological age and school year. As exclusion criteria, schoolchildren who did not present the Free and Informed Consent Term signature, with the presence of sensory (hearing and/or visual impairment) and cognitive deficits described in school records and/or in neuropsychological assessment findings and who participated in speech therapy and pedagogical remediation.

As procedures, the schoolchildren were submitted to the following assessments, individually, lasting up to 4 sessions, with approximately 30 minutes, as follows: 3.1 Phonological skills assessment protocol (PROHFON- Germano & Capellini, 2016): composed of 12 tests that assess the student's performance in phonological awareness, allowing classification by test and school year. 3.2 Visual Perception Development Test III - DTVP III (Hammill, Pearson, & Voress, 2014). This protocol consists of a battery of five subtests that measure different visual-motor and visual-perceptual skills

After applying the assessments, the GI schoolchildren were separated according to the profiles of the dyslexia subtypes. For the separation in the diagnostic profiles, the following criteria were considered:

- Phonological Profile. To compose the phonological subtype, we considered the classification “under attention” in more than 50% of the phonological skills subtests (PROHFON – Germano & Capellini, 2016) and performed within and/or above average for the visual subtests (Figure – Background; Visual Closing; and Constancy of shape) and for the composite score of reduced motor perception of the visual perception test (DTVP-III; Hammill et al., 2014). A total of 22 schoolchildren met this criterion.

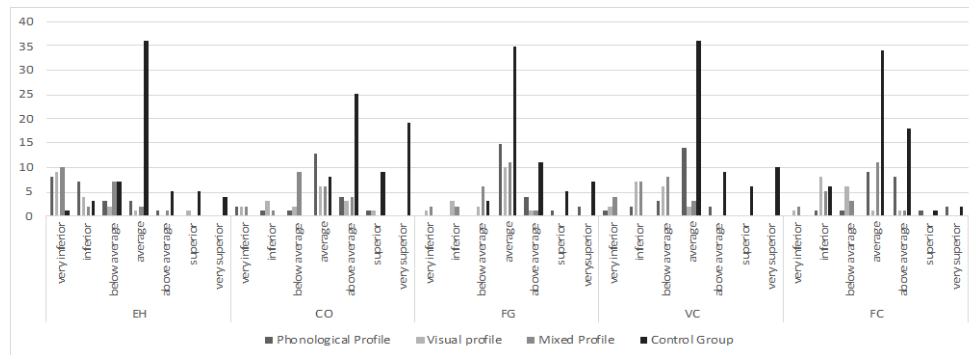
- Visual profile. To compose the visual subtype, we considered schoolchildren who performed “expected” in more than 50% of the metaphonological skills subtests (PROHFON, Germano & Capellini, 2016) and presented below average performance for the visual subtests (Figure – Background; Visual closure; and Shape constancy) and for the composite score of reduced motor perception of the visual perception test (DTVP-III; Hammill et al., 2014). A total of 17 schoolchildren met this criterion.

- Mixed. To compose the mixed subtype, we considered schoolchildren who performed “under attention” in more than 50% of the metaphonological skills subtests (PROHFON, Germano & Capellini, 2016) and presented below average performance for the visual subtests (Figure – Background; Visual closure; and Shape constancy) and for the composite score of reduced motor perception of the visual perception test (DTVP-III; Hammill et al., 2014). A total of 22 schoolchildren met this criterion.

4. RESULTS

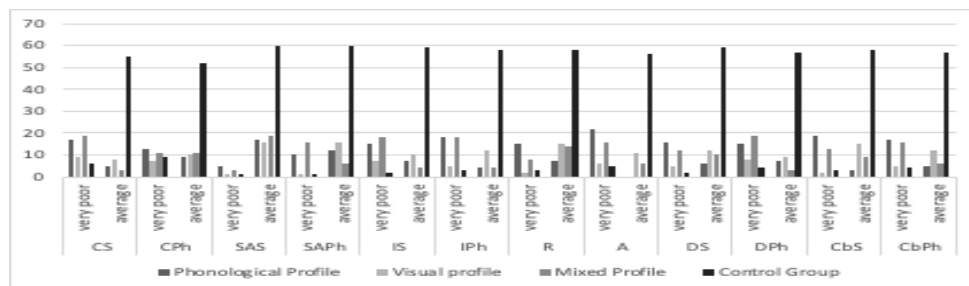
Figure 1 and 2 show the performance classification for the visual and phonological variables, respectively. The Likelihood Ratio Test was applied for comparison between categorical variables, that is, according to the classification of procedures. All variables showed significant differences.

Figure 1.
Distribution of performance classification of visual variables.



Caption: EH: hand-eye coordination; CO: Copy; FG: Figure –ground; VC: Visual closure; CF Shape Constancy

Figure 2.
Distribution of performance classification of phonological variables.



Caption: S: syllable; Ph: C: Count; SA: Synthesis and Analysis; I: Identification; A: Rhyme; A: Alliteration; D: Deletion; Cb: Combination

5. DISCUSSION

The findings of this study allowed us to observe that Brazilian schoolchildren with dyslexia showed differences in performance regarding phonological aspects and visual perception, indicating the heterogeneity of dyslexic manifestations.

Specifically, it was possible to observe that the phonological subtype was characterized by deficits in the phonological skills of syllable and phoneme synthesis and analysis, alliteration, and syllable combination. Phonological deficits primarily affect pseudoword reading, although they also prevent the normal acquisition of lexical orthographic knowledge (Share, 1995, 1999).

The issue of phonological deficit has been discussed for at least 30 years (Wagner & Torgesen, 1987), highlighting that schoolchildren with dyslexia fail in three dimensions, namely phonological awareness, short-term verbal memory and lexical recovery. Thus, understanding that the three dimensions are affected together as they imply phonological representations, each in its own way. In this study we observed failures in the first

dimension, phonological awareness. Ramus and Szenkovits (2008) proposed that the phonological difficulties of dyslexics were related to phonological access. For the authors, phonological awareness tasks require the subject to maintain segmented phonological units in short-term memory, as well as requiring conscious access to these representations, and such tasks overload short-term memory. Verbal short-term memory requires access to phonological representations in order to copy them into buffers, then access to phonological buffers for retrieval, as well as access to input representations in order to copy them into output representations, and access to output representations to recycle them into input representations, that is, the phonological loop, as described by Baddeley (1984). Phonological awareness tasks additionally involve a special type of access, conscious access to phonological representations, which may place special demands on access mechanisms. Therefore, it seems to us that people with dyslexia tend to fail in particularly demanding tasks in terms of phonological access.

As for the visual subtype, its characteristics were deficits in visual motor skills, visual figure-ground and constancy of form. Visual figure-ground is a high-level discrimination skill, the student must recognize relevant lines and curves and, simultaneously, disregard unimportant ones. The teaching of visual figure-ground activity can help the student to give adequate and concentrated attention to relevant stimuli, ignoring irrelevant ones (Fusco, Germano, & Capellini, 2015; Frostig, Horne, Miller, & Lorenzo, 1984). Regarding constancy of form, it enables student to develop the ability to generalize in relation to the visual stimulus, as well as the identification of geometric shapes and learned words, regardless of their size, color, shading or positioning (Frostig et al., 1984).

The results of this study corroborate Feagans and Merriwether (1990), who observed a positive correlation between visual discrimination skills and reading performance, and children with stronger visual discrimination skills tended to perform better on the lowercase letter identification task (Woodrome & Johnson, 2009). Before learning to identify letters, schoolchildren must learn to discriminate between similar two-dimensional figures, in order to later make phonemic access. The findings of this study suggest that difficulties in the skills of shape, figure and background constancy and visual closure can contribute to the failure of this recognition, causing an impact on reading. As indicated by Woodrome and Johnson (2009), if a children cannot differentiate the letters, it will be difficult to learn the names of the letters, resulting in poor reading performance. Additionally, studies indicated that visual skills are an important predictor of future reading performance, and this relationship may change with development (Kavale, 1982; Kavale & Forness, 2000).

The difficulty in acquiring these skills contributes to the promotion of the visual subtype. Studies indicate that directional visual perception is necessary for children at the beginning of the process of learning to read, as it precedes access to semantic and syntactic information (Bakker, 1992; Satz & Sparrow, 1970; Woodrome & Johnson, 2009). Thus, children must learn to differentiate between symbols (e.g., ‘p’, ‘b’ and ‘d’) before they can relate sounds to letters and read words. Visual discrimination skills contribute to learning to read, facilitating the acquisition of letter knowledge, which is one of the strongest predictors of future reading ability (Badian, 1994; Catts, Fey, Zhang, & Tomblin 2001; Sawyer, 1992; Woodrome & Johnson, 2009). Thus, for the visual subtype of this study, we can infer that the representations of letters may not have occurred satisfactorily, causing difficulty in establishing the grapheme-phoneme conversion at the time of reading, due to poor visual perception rather than phonological awareness.

Therefore, these schoolchildren with difficulties in visual perception and the absence of phonological deficits alert us to the need to investigate these profiles in the population, in addition to the fact that the findings corroborate literature that indicates that dyslexic

readers may have other problems that do not only involve phonological deficits (Castles & Coltheart, 1993).

The findings of this study indicate that it was possible to identify subgroups of dyslexic children in terms of visual and phonological abilities, and these discoveries clearly document the existence of individual differences in the dyslexic population. Thus, cases of developmental dyslexia with normal phonological processing have been documented (Valdois, Bosse, & Tainturier, 2004), despite the use of sufficiently sensitive phonological measures. Another important aspect observed is in relation to phonological skills. When observing the distribution of schoolchildren regarding performance classification, it is noted that all subtypes had some phonological impairment. That is, we can infer that dyslexic had failures in accessing the phoneme, in some way. This aspect can be related to the current literacy methodology in Brazil, which does not prioritize the systematic and reflective teaching of grapheme-phoneme conversion.

In the study by Germano et al. (2014) it was also possible to verify schoolchildren with the absence of visual and phonological deficits, based on other classification criteria, which were called the "no disorder" group. Authors had suggested that visual processing and phonological processing may independently contribute to reading ability. Such findings indicate that the heterogeneous profile of dyslexia goes beyond visual and phonological deficits. The literature has addressed the existence of schoolchildren who are less likely to demonstrate decoding difficulties, but who have specific difficulties in reading comprehension.

The children in the "no disorder" group showed impairments in reading, but not justified by deficits in phonological and visual skills. In this study, the "no disorder" group was identified as being composed of students diagnosed with dyslexia, but who did not have significant deficits in visual-attentional or phonological skills. This finding has a very important implication for clinical diagnostic investigation, as conventional assessment batteries would not be sufficient to identify these profiles, requiring the application of refined criteria such as accuracy and reading speed, as provided for in DSM-V (APA, 2014). In addition, it's possible that they might have suffered a limited experience with the language used in written texts (Graves et al., 2014).

In a recent meta-analysis study (Georgiou et al., 2022), suggested that reading comprehension deficits in individuals with dyslexia are likely the product of deficits in both decoding and oral language skills. Authors highlight that individuals with dyslexia experience great difficulties in reading comprehension and this reinforces the notion of considering reading comprehension a secondary symptom of dyslexia. This study corroborates our findings, which reiterate that the reading difficulties experienced by dyslexic's have several levels, ranging from the underlying reading skills (i.e., visual and phonological processing) to reading comprehension.

These studies, together with ours presented here, move towards the understanding that dyslexia need to be seen as a heterogeneous impairment, and that the clinical evaluation process should include different protocols, to better characterize each individual profile.

Based on this understanding, and following global research trends, educational and interventional implications should also be considered. In Brazil, in addition to the reading programs used in clinics by speech-language pathologists, programs based on the educational model of response to intervention (RTI) began to be implemented in the educational environment, focusing on phonological and visual aspects. Such programs enabled the early identification and referral of children with dyslexia, favoring access to treatments and the discussion of curricular adaptations (Cerqueira César, Germano,

& Capellini, 2018; Fletcher, & Vaughn, 2009; Fusco et al., 2015; Germano, César, & Capellini, 2017; Vaughn, Miciak, Clemens, & Fletcher, 2024).

Daniel, Clucas and Wang (2024) also discuss the misconceptions held by professionals who treat dyslexics. The authors emphasize that dyslexia need to be understood in its entirety, and that misconceptions prevent a more accurate diagnosis and, subsequently, the targeting of appropriate interventions, whether in the clinical or educational context.

In any ways, Zoccolotti (2020) draws our attention to the analysis of reading behavior, that is, the assessments emphasize the quantitative analysis and functional significance of the reading deficit (as well as exclusion criteria, such as sufficient educational opportunities and lack of general sensory or intellectual problems), severity and relevance of reading difficulties. From this perspective, in agreement with the findings of this study, especially with “no disorder” group, the author defines dyslexia as a complex behavioral disorder, characterized by low performance on standardized reading tests and significant impairment in daily life (mainly in school activities). In this way, dyslexia can be better understood when seen in a multilevel analysis approach, a perspective originally claimed by Frith (1999), who already highlighted that behavioral aspects of dyslexia would extend far beyond problems with written language.

In addition, Pennington (2006) proposed the multiple deficit model of neurodevelopmental disorders in an attempt to explain multiple deficits related to dyslexia, rather than the traditional single deficit model. An interesting point of multiple deficits is the interindividual variability in the profiles, proposing that each risk factor is probabilistically (and not deterministically) related to neurodevelopmental disorders, as pointed out by McGrath, Peterson, and Pennington (2020). This aspect entails not only theoretical implications, but also in terms of clinical and educational practice, as it denotes the need for interventions with phonological remediation programs, even in the case of a visual subtype.

Finally, the findings of this study also agree with Wolf et al. (2024), who discuss the need for a new definition of dyslexia, since traditional definitions do not encompass the different models and studies carried out in recent decades. The authors advocate a definition that the still evolving history of attempts to explain dyslexia, including in varied writing systems, and the study of the reading brain circuit, its development, and its genetic and environmental influences. Thus, the study described in this chapter, with the Brazilian reality, corroborates international studies, highlighting the view of dyslexia as a specific reading disorder, but with heterogeneous manifestations.

6. FUTURE RESEARCH DIRECTIONS

Research on dyslexia subtypes in Brazil has shown that there are heterogeneous profiles, which have an impact on identification and intervention. The continuity of these investigations is important to better characterize this population.

Therefore, this chapter brings as future directions the need to review clinical and educational practices, in terms of carrying out assessments with different procedures, which range from the underlying processes of decoding (phonological and visual processing) to the processes of reading comprehension. With this, the way of intervening in individuals with dyslexia will also undergo changes, since the delineation of the student's profile will favor a better direction for clinical and educational intervention.

7. CONCLUSION

The findings of this study allowed us to observe that Brazilian schoolchildren with dyslexia showed differences in performance regarding phonological aspects and visual perception, indicating the heterogeneity of dyslexic manifestations. These findings contribute to the discussion about the diagnostic criteria used by professionals, in addition to increasing the need to implement intervention programs with visual and phonological approaches. The findings of this study are in line with international studies, which have indicated that dyslexia should be seen as multimodal, with varied impairments that go beyond traditional conceptions.

Clinical and educational professionals must be prepared to make curricular adaptations aimed at a more individualized profile, allowing access to intervention programs based on phonology and/or visual language, which will impact decoding skills and consequently reading comprehension. What emerges from this study is a dynamic conceptualization of dyslexia that corroborates other research on the heterogeneity of dyslexia, which highlights the interdependent contributions of multiple biological and sociocultural risk and prevention factors. Critical to the social understanding of dyslexia is that, although typically described as a specific learning disability, dyslexia is a learning difference that becomes a disability when environments are disabling. Furthermore, individuals with dyslexia may be impacted not only academically, but also socially, emotionally, and occupationally.

Finally, these findings alert us to the need to better understand the student's profile to improve curricular adaptation policies.

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Chapter # 8

ADAPTING TO CRISIS: A CASE STUDY IN EMERGENCY ONLINE FACULTY DEVELOPMENT

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ABSTRACT

The University of Central Florida (UCF) shifted to remote online instruction during the Spring of 2020 due to the COVID-19 pandemic, revealing gaps in faculty development for online teaching. This case study examines how UCF utilized its online pedagogy expertise and resources to create an emergency faculty development program. Through semi-structured interviews and document analysis, five key themes emerged: leadership challenges, reliance on existing resources, implementation barriers, foundational LMS tutorials, and strategies for diverse faculty needs. Findings showed that instructional designers adapted resources rapidly, defined training objectives, and supported faculty engagement despite challenges like departmental resistance. The study compared UCF's approach to those of other institutions, highlighting common issues such as tight timelines, diverse faculty needs, and effective practices like peer mentoring and data-driven design. The study concludes with recommendations for improving emergency faculty development programs, focusing on modular training, leadership support, peer collaboration, and accessibility. It offers valuable insights for institutions seeking to build resilient and inclusive faculty development frameworks for future emergencies.

Keywords: online learning, faculty development, pandemic.

1. INTRODUCTION

The COVID-19 pandemic forced many universities to adapt rapidly, revealing significant gaps in faculty development for online teaching during emergencies. As a major global health crisis, COVID-19 led to the closure of schools and colleges worldwide (Centers for Disease Control and Prevention, 2020). Faculty members faced challenges transitioning in-person courses, like laboratory work and cooking demonstrations, to an online format. The immediate shift to remote learning required instructors to quickly learn online teaching strategies (Dvir & Schatz-Oppenheimer, 2020). While some faculty and students were familiar with remote education, many struggled due to limited knowledge of online platforms, with effective communication being a key challenge (Gillis & Krull, 2020). Despite these difficulties, some faculty reported high satisfaction with the technological tools they learned to use, appreciating the new opportunities for innovative teaching. However, they also faced tensions regarding their instructional goals and teaching effectiveness (Dvir & Schatz-Oppenheimer, 2020).

This study examined how a public state university met the challenge of supporting hundreds of faculty members as they quickly transitioned to online course delivery during the 2021-2022 academic year. Using a case study approach (Creswell, 2015), the researchers investigated how the University of Central Florida (UCF), a nationally recognized leader in

online learning with a student body exceeding 70,000, adapted to the crisis and assisted its faculty in moving to a fully remote environment. UCF, which offers more than 240 degree programs and consistently ranks among the top institutions for online learning according to *U.S. News & World Report*, relied heavily on its Center for Distributed Learning (CDL) to spearhead these efforts. CDL supports the university's online faculty development programs by providing resources such as an online help desk, learning management system (e.g., Canvas) administration, instructional development, multimedia resources, and instructional design, all of which enhance the quality of online instruction at the university level. Central to the study are the unique insights of instructional designers, whose experiences illuminate the program's development process and impact. By applying Yin's (2008) qualitative case study framework, this research provides a detailed and comprehensive account of the strategies, challenges, and successes that characterized faculty development in online teaching during one of the most transformative periods in higher education.

2. BACKGROUND

Throughout the 20th century, the impacts of national emergencies on higher education have been profound. National emergencies, such as wars, pandemics, and economic crises, have demanded rapid adaptations by colleges and universities, often leading to significant transformation. For example, 2005's Hurricane Katrina devastated New Orleans and profoundly impacted higher education institutions in the region, including student displacement, substantial drops in enrollment, and extensive damage to institutional infrastructure (Madrid & Grant, 2008; Raker et al., 2019). The legacy of Katrina for higher education in the region includes integrating disaster education into the curricula across various disciplines (Rivera & Miller, 2008). Similarly, the effects of the 2009 L'Aquila earthquake in Italy include a significant decline in student enrollments that resonated for years following the disaster (Cerqua & Di Pietro, 2016). In developing countries, natural disasters have posed an even more significant challenge for higher education institutions. The effects of such disasters often include the destruction of educational infrastructure, loss of academic staff, and displacement of students, which collectively hinder educational attainment and access. For example, natural disasters can undermine already vulnerable economic resilience and disrupt educational systems, particularly in geographically isolated communities (Hidayat, 2023; Shaw, 2020).

Adapting to new situations without institutional support can be challenging for faculty. The sudden shift to remote online learning caught many off guard, as they had to address previously unencountered problems (Flores & Swennen, 2020). A 2020 study by Van der Spoel, Noroozi, Schuurink, and van Ginkel surveyed 200 Dutch instructors and found that prior experience with learning management systems significantly eased the transition to remote instruction. Faculty members reported feeling a heightened urgency to adapt, but they also noted that the lack of interaction with students and colleagues was a major drawback (Van der Spoel et al., 2020). Despite these challenges, online instruction offered benefits. Many faculty observed that introverted students engaged more during online learning than in traditional settings. Faculty also expressed enthusiasm for integrating technology into their teaching post-COVID, aiming to promote active learning and improve feedback (Van der Spoel et al., 2020). Technology increased efficiency and motivated students through personalized experiences. The urgency of the pandemic has led faculty to continue incorporating technology into their lessons, even without professional development support (Gupta, 2021; Wyatt, Aburto, & How, 2023). However, it remains essential for faculty to stay motivated to use online tools after returning to in-person teaching.

In the early months of the COVID-19 pandemic, faculty members experienced varying levels of preparedness for online teaching, which increased stress and diminished teaching effectiveness (Kirschner, 2021; Zizka & Probst, 2021). A major challenge was engaging students, with research showing that about 65.7% of faculty perceived lower student participation in online classes compared to face-to-face settings (Khan & Jamil, 2022). This contributed to a sense of disconnection between faculty and students (Rahman, 2023). By 2021, around 30% of college students were enrolled in at least one online course, with expectations for this number to grow as institutions adapted (Bartek, Pellegrino, White, & Clayton, 2022). This shift illustrates a fundamental change in education delivery. While both faculty and students became more proficient with technology (Chhetri, 2022), many still felt that online learning fell short of traditional classroom effectiveness, highlighting ongoing concerns about education quality and learning outcomes (Almendingen, Morseth, Gjelstad, Brevik, & Tørris, 2021; Shirazi, Shekhani, & Moazam, 2022).

The Organisation for Economic Co-operation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) emphasize preparing students for an uncertain future (Hadar, Ergas, Alpert, & Ariav, 2020). The COVID-19 pandemic exposed gaps in faculty development, particularly in social-emotional competencies. A study of 54 student teachers and 24 educators highlighted challenges with remote instruction and teaching skills (Hadar et al., 2020). To address these gaps, institutions should integrate stress management, mindfulness, and teamwork into professional development. The pandemic also revealed the need for innovative methods and resources to promote educational equity and sustainability (Chans, Orona-Navar, Orona-Navar, & Sánchez-Rodríguez, 2023). Overall, it is clear that public institutions must prioritize faculty preparedness to ensure adaptability during crises.

3. OBJECTIVES

The following research questions guided this study:

RQ1: According to instructional designers involved in creating the crisis-responsive faculty development program *Essentials of Online Teaching (EOT)*, what factors influenced this large-scale program's design and development to support faculty during an emergency?

RQ2: According to instructional designers who contributed to the development of the crisis-responsive faculty development program *Essentials of Online Teaching (EOT)*, what were the primary challenges and urgent obstacles faced during its rapid implementation to accommodate a substantial number of faculty participants?

4. METHODS

A qualitative case study design consisting of interviews and document analysis was used to analyze the phenomenon comprehensively. A qualitative case study design is an intensive examination of a bounded system, which can be a single entity or multiple entities over time. This definition emphasizes the importance of context and the holistic nature of the research, as it seeks to capture the complexity of real-life situations (Yilmaz, 2024). Researchers employing this design often utilize various data collection methods, including interviews, observations, and document analysis, to gather comprehensive insights into the case. The qualitative nature of this approach allows for flexibility in data collection and analysis, enabling researchers to adapt their methods as new findings emerge (Guetterman & Fetters, 2018).

4.1. Participant Recruitment

Eight participants, all instructional designers, were involved in designing, developing, and implementing the online faculty development program. These participants also supported faculty members throughout the program, ensuring the successful completion of their training. Participants were personally invited through email. Two participants had experience in at least one of the following four areas related to the rapid online faculty development course in response to COVID-19:

- Online course design,
- Implementation and development of the online course,
- Design and development of course evaluations, and
- Course facilitation.

4.2. Data Collection

The primary data source for this study was derived from interviews, which were complemented by a thorough analysis of relevant planning and implementation documents. The researchers employed a structured approach to data collection through scheduled, consensual interviews that adhered to a semi-structured protocol. This methodology facilitated the elicitation of responses through a combination of closed and open-ended questions, thereby enabling a comprehensive exploration of the research questions (Creswell, 2015; Yin, 2008). To ensure the confidentiality of participants, each interviewee was assigned a pseudonym. All interviews were conducted via Zoom, a widely utilized web-based video conferencing platform, where audio recordings were securely saved and subsequently transcribed within the same environment.

In addition to interview data, the study incorporated documents from publicly accessible sources, including institutional websites and repositories provided by the development team and relevant stakeholders. The selection of these materials was guided by their pertinence to the design, implementation, and adaptation of the faculty development program in response to the challenges posed by the COVID-19 pandemic. This dual approach of qualitative interviews and document analysis enriched the research findings, providing a multifaceted understanding of the program's dynamics during an unprecedented global crisis.

4.3. Data Analysis

The researchers used a qualitative research approach involving thoroughly examining and interpreting interview transcripts and existing documents to gain insights into the faculty development program. Regarding the analysis of qualitative interview data, the researchers employed a deductive analytical approach guided by constructivist principles. They applied coding and clustering techniques to identify key themes related to participants' attitudes, beliefs, and values. This process involved four coding cycles, with the final phase yielding themes that directly addressed the research questions. To ensure the accuracy of their findings, the researchers utilized Dedoose, a qualitative analysis software tool.

The researchers collected publicly available documents, including institutional reports, COVID-19 response plans, student support documents, faculty development plans, meeting agendas, and facilitation materials. Initially, these documents were organized according to institutional needs and program objectives. A comprehensive analysis of these documents produced contextual and detailed insights into the program's design and implementation. By applying Bowen's (2009) systematic procedure, the researchers reviewed and evaluated the documents to extract key information, identify patterns and themes, and highlight strategies for addressing the needs of faculty and students.

5. FINDINGS

While instructional designers struggled with limited leadership direction and the broad range of faculty needs, developers faced compressed timelines to produce training materials rapidly. Implementers managed skepticism and resistance from certain faculty groups, and evaluators encountered difficulties gathering comprehensive feedback due to limited analytics.

Table 1 depicts the program's roles and how they are interconnected. Instructional designers played a critical role by adapting resources and defining training objectives. Developers streamlined materials to ensure rapid development, implementers facilitated faculty engagement, and evaluators identified critical areas for future improvement. Together, these roles show the multifaceted picture of faculty development in a crisis.

Table 1.
Summary of Challenges, Strategies, and Outcomes Related to Participants' Roles.

Role	Key Challenges	Strategies Employed	Outcomes
Instructional Designers	Lack of leadership direction, tight timelines, and diverse faculty needs.	Leveraged existing resources, streamlined credentialing processes, and adapted content.	Established quality in training, albeit with limited scalability and differentiation.
Developers	A high volume of content to create and compress within a limited time.	Simplified course templates and repurposed pre-existing LMS tutorials.	Ensured rapid deployment of training but faced limitations in customization for advanced users.
Implementers	Skepticism from faculty in large, traditionally hands-on departments (e.g., Sciences, Education).	Encouraged faculty engagement via peer mentoring and success stories.	Increased buy-in in resistant departments but noted the need for enhanced departmental outreach.
Evaluators	Limited feedback mechanisms and lack of robust analytics to assess effectiveness.	Collected qualitative feedback through interviews and limited surveys.	Highlighted gaps in advanced training and areas for program improvement.

5.1. Challenges in Establishing a Starting Point

Participants reported difficulties determining a starting point for how and where to start the development, citing a lack of clear direction from the university and program leadership. Several instructional designers reported feeling “overwhelmed” and “lost” by the absence of

guidance. These instructional designers also suggested that the lack of direction may have delayed their progress and increased reliance on other colleagues or peers as support. This theme highlights the importance of leadership in providing structure and minimizing uncertainty. These findings align with Transactional Distance Theory, emphasizing distance education's psychological and communicative gaps when structure and dialogue are insufficient (Moore, 1997). Applying Bowen's (2009) systematic procedure revealed inconsistencies in leadership communication, as institutional documents lacked the clarity necessary for effective implementation.

5.2. Defining Purpose and Intent of Training

The instructional design team aimed to align the program with faculty needs and institutional goals by establishing clear objectives. They adapted existing resources, including a semester-long credentialing process in pedagogy and technology, for remote instruction, focusing on effective use of the learning management system (LMS), Zoom best practices, and faculty credentialing. This strategy follows Backward Design principles, which begin with desired outcomes to develop curriculum and assessments (Childre, Sands, & Pope, 2009; Rea & Román, 2019; Wiggins & McTighe, 1998). By prioritizing faculty readiness and student engagement, the team ensured that training upheld pedagogical integrity while addressing urgent needs. Initial program goals targeted basic technical competencies, aligning with foundational resources while planning for advanced modules. Using Bowen's (2009) systematic procedure, researchers identified how adapting existing resources addressed immediate gaps. Institutional documents revealed that the program's initial goals targeted technical competencies, aligning with the team's strategy for foundational resources while planning advanced modules.

5.3. Barriers to Implementation

Participants faced several barriers during the faculty development program's implementation, mainly due to the rapid shift to online instruction. The program, which usually spans ten weeks, was condensed to a few weeks due to pandemic pressures. This accelerated timeline forced the instructional design team to prioritize content over quality. One participant remarked, "We had to make tough decisions about what to prioritize." Consequently, there was little time for feedback, leaving some faculty feeling unprepared for online teaching. The diverse backgrounds of faculty—ranging from novices to experienced educators—complicated matters. Although the design team aimed to offer flexible training, the urgency hindered their ability to differentiate content, resulting in unmet participant needs. Researchers identified scalability and differentiation as key challenges, with initial plans for tailored training pathways sidelined by time constraints and limited resources (Bowen, 2009).

5.4. Reliance on LMS Tutorials

The program utilized a self-paced Learning Management System (LMS) tutorial for faculty training, requiring a minimum of 40 hours to complete. It covered basic LMS navigation and functionality but did not address advanced topics in course development, instructional design, or online pedagogy, leaving gaps for experienced faculty. Bowen's (2009) procedure indicated that the tutorial was accessible but technical, lacking depth in teaching strategies. Training materials noted the need for additional resources, which were deprioritized due to time constraints.

5.5. Addressing Diverse Faculty Needs

The faculty participants in the program had diverse backgrounds, leading to challenges for the instructional design team in addressing varying levels of experience with online learning. Bowen's (2009) document analysis confirmed that faculty needs were a critical factor, with pre-training assessment data indicating missed opportunities to tailor resources. These findings highlight the need to balance baseline training with advanced modules to meet varying expertise levels effectively.

5.6. Summary

The findings highlight the complex challenges of developing a faculty development program during a crisis, including the need for leadership direction, goal-oriented planning, and scalable solutions to address diverse faculty needs. The team successfully navigated many challenges by leveraging existing resources and focusing on collaborative design, offering valuable insights for future initiatives.

6. COMPARATIVE APPROACHES TO EMERGENCY ONLINE TEACHING

As a leader in online education, Arizona State University (ASU) effectively transitioned to emergency online teaching by rapidly scaling existing courses and providing faculty with pre-designed templates and week-long boot camps for those new to online instruction. This approach is similar to that of the University of Central Florida (UCF), built upon its established online infrastructure. However, ASU's use of templates contrasts with UCF's more individualized course design.

In contrast, Harvard University emphasized innovation by launching a "Teaching Remotely" website that offered resources and established a peer support network. This focus on pedagogical innovation enhances UCF's structured faculty development program. The Community College of Baltimore County (CCBC) prioritized equity by providing loaner laptops and Wi-Fi hotspots, developing simplified course templates, and supporting trauma-informed teaching. This focus on accessibility is an area UCF could explore further, given its diverse student population. The University of Michigan (n.d.) took a data-driven approach, analyzing Learning Management System (LMS) data to inform faculty development and identify at-risk students. This contrasts with UCF's qualitative assessments and suggests opportunities for improvement through learning analytics.

Common themes emerged from these institutions' responses to online teaching challenges: the importance of established infrastructure, prioritizing faculty development, adapting teaching methods, ensuring access to technology, and using data to enhance online practices. UCF's strengths lie in its existing infrastructure, comprehensive faculty development program, and focus on online course quality. However, there are opportunities for growth in enhancing peer support networks, increasing learning analytics use, and expanding focus on equity and accessibility. While UCF aligns with many best practices, learning from other institutions could further refine its approach to faculty development for online teaching.

7. DISCUSSION

The comparative analysis of institutional approaches to emergency online teaching in Section 6 provides valuable context for UCF's faculty development program. The swift shift

to online learning required innovative solutions, and UCF aligns with best practices by leveraging its existing online infrastructure and offering strong faculty support. For instance, UCF's method of building on established online resources is similar to Arizona State University's, highlighting the need for continued investment in online capabilities as a preparedness strategy.

Defining the faculty development program's purpose guided its design. Participants used Wiggins and McTighe's (1998) "backward design" framework to set goals and plan content based on faculty needs. Recognizing the time constraints amplified by COVID-19, the team established an efficient timeline and workload distribution, emphasizing clear communication about delays. The analysis reveals opportunities for UCF's growth. Harvard's peer support network model could enhance faculty collaboration and knowledge sharing. One instructional designer noted the potential for more peer-to-peer learning opportunities, which could strengthen the existing program. Additionally, adopting a data-driven approach similar to the University of Michigan's could yield deeper insights into effective teaching practices, enhancing faculty support.

Moreover, initiatives at the Community College of Baltimore County demonstrate the need to address diverse student needs more thoroughly within UCF's faculty development program. Enhancing training on accessible materials and strategies for supporting technology-challenged students could be beneficial. To build on its strong foundation, UCF might consider implementing a peer mentoring system, expanding learning analytics for better program evaluation, and enhancing the focus on equity and accessibility. Developing flexible, modular training options could also cater to diverse faculty needs, increasing participation and engagement. By incorporating these enhancements, UCF can continue to innovate in faculty development for online teaching.

8. IMPLICATIONS OF THE STUDY

This case study emphasizes the importance of establishing a timeline and understanding what can realistically be achieved. Participants pointed out that time constraints significantly affected their ability to design and facilitate a faculty development program. Instructional designers (IDs) needed to ensure their time was productive while considering the workload and the time faculty could commit to the course. Faculty engagement decisions impacted participant focus and progress, making it essential to maintain manageable expectations for participation. Collaboration among IDs proved effective in overcoming program design and development challenges. IDs could leverage their expertise to create effective faculty development solutions by working together towards a shared goal. This collaborative environment fostered innovation, efficiency, and transparent communication. Creating a culture of collaboration enhances work outcomes and allows IDs to learn from each other, encouraging open feedback and knowledge sharing. This emphasis on learning and development enriches the workplace culture. Higher education institutions often face crises that disrupt access to learning. While response teams focus on safety, they frequently neglect continuity in education. Lessons from the pandemic showed that better LMS utilization and adequate faculty training could have lessened the impact of shutdowns. Fundamental elements, such as LMS training, a design response team, and a contingency plan, can help facilitate a smooth transition to remote instruction without harming faculty and students.

9. CONCLUSION

This case study examined key practices used by instructional designers at UCF to create and implement the EOT faculty development program in response to the COVID-19 pandemic's shift to online instruction. Semi-structured interviews revealed that instructional designers felt a strong sense of collaboration and connectedness, enabling them to clearly define the program's purpose despite limited time and leadership direction. This research addresses gaps in the literature regarding faculty development during the pandemic and highlights the challenges instructors and students faced due to limited experience with online teaching and communication barriers (Gillis & Krull, 2020).

Future initiatives should prioritize institutional preparedness for emergencies and focus on seamless transitions to remote learning to overcome these barriers. Equity considerations, such as those adopted by the Community College of Baltimore County, could help UCF better serve its diverse student population. Modular training programs, like Arizona State University's boot camps, offer flexible, time-sensitive solutions tailored to faculty needs. Drawing on these strategies presents opportunities for UCF to refine its already strong faculty development programs.

In conclusion, this study emphasizes the importance of institutional readiness, collaborative instructional design, and adaptive faculty development in addressing educational emergencies. Lessons from UCF and other institutions provide valuable insights for advancing faculty development in online and blended learning environments, ensuring they meet the dynamic needs of higher education in a rapidly evolving landscape.

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Chapter # 9

UNDERSTANDING OF PRE-SERVICE TEACHERS' MATHEMATICAL KNOWLEDGE AND PERCEPTIONS OF TEACHING

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ABSTRACT

The objective of the present study is to analyze pre-service teachers' mathematics knowledge base as a relationship between their substantive subject mathematics knowledge and syntactic subject mathematics knowledge. The theoretical approach refers to Shulman's pedagogical content knowledge and Ball, Thames and Phelps' subject matter knowledge for the teaching concept. The participating pre-service teachers (PSTs) were divided into two groups: 20 from a program course for K–3 teachers and 25 from a program course for grade 4–6 teachers. The crucial mathematical content for the study was algebraic patterns, rational numbers (fractions), proportionality and elements of combinatorics. The findings show the importance of gaining a better insight into and understanding of student teachers' learning process and challenges related to the mathematics knowledge base (e.g., its substantive and syntactic components). The benefits of the empirical findings are that they led to new knowledge and a deeper understanding of PSTs' learning of mathematical concepts through two learning processes (SUB and SYN), as well as the relationship and shift between these processes.

Keywords: preparation of pre-service teachers, mathematics knowledge base, substantive subject matter knowledge, syntactic subject matter knowledge, mathematics for teaching.

1. INTRODUCTION

Mathematical preparation of PSTs plays a crucial role in developing their ability to teach mathematics and has a strong impact on their students' learning of mathematics. The quality of teacher education is an important topic of research in both a national and an international context. There is a need to expand our knowledge of PSTs' learning of mathematics, how to activate and systematize their prior subject knowledge, how to foster the transition from prior knowledge into knowledge for teaching mathematics, and how the interplay between theoretical knowledge and knowledge of practical teaching should be organized (Wilson, Floden, & Ferrini-Mundy, 2001). Wilson et al. (2001) also report that PSTs' knowledge of teaching content and practical teaching is often separated from, or poorly coordinated with, the theoretical part of their education. Student teachers' perceptions of mathematics teaching are often limited to mechanical learning (counting). One of the major challenges is creating continuity in PSTs' learning of mathematics, in which theoretical knowledge is developed in close connection with knowledge of mathematics teaching in school. A key prerequisite for achieving this is to find practice schools where teachers share the teacher educators' views of knowledge and learning (p. ii). Recent studies (Radovic, Black, Williams, & Salas, 2018; Zazkis, Leikin, & Chavoshi Jolfae, 2011) confirm that there is still a need for a more comprehensive understanding of

the kind of mathematics knowledge PSTs need to develop in order to enable high-quality teaching after they have graduated.

There is currently limited research on effective strategies to teach PSTs' mathematics and mathematics didactics in a way that can provide them with the necessary teaching skills through practical experience in schools, while also providing them with a deeper understanding of the crucial role of theoretical knowledge (Olawale, 2024). The combination of theory and analytical observation of teaching practice provides student teachers with the experience they need to access and understand mathematics, both for their own benefit and for the benefit of their future students. Access to theory and practice means that student teachers will have continuity in their mathematical development and in the planning of teaching content with a focus on students' learning. This means that PSTs and their future students will successively learn the internal structures of mathematical concepts through conceptual and procedural meaning which, in turn, must be generalized with the aim of understanding mathematics as an abstract subject. In order to implement such a process and ensure learning in the classroom, student teachers must be able to process and produce knowledge in relation to their own learning and their students' learning. In other words, they must be able to take a second-order perspective on their students' learning, which is intimately connected to a first-order perspective on their own learning of mathematics (Leatham, 2006). This requires self-awareness and an understanding of how mathematical knowledge is perceived and developed, and of the misconceptions that can arise in their own learning and their students' learning. Much like incorrect generalizations during their early school years, students' misconceptions of mathematical concepts and methods can have a significant impact when they reach lower and upper secondary school, as well as teacher education (Kajander, 2005; van Dooren, De Bock, & Verschaffel, 2010). In order to promote students' learning of mathematics and identify any misconceptions, PSTs must have solid knowledge of mathematics that is rooted in practical mathematics teaching.

2. BACKGROUND

The importance of mathematical knowledge and the conceptual context in which PSTs and their future students are taught has been described as *subject mathematics knowledge* for teaching by researchers such as Shulman (1986) and Ma (1999). Empirical studies of teachers' mathematical knowledge suggest that PSTs need to make a transition from a student's perspective to a teacher's perspective in order to engage in self-reflection on their own learning process of mathematical content, as well as understand how students learn the same content based on their different abilities, knowledge and, conditions for developing conceptual knowledge. In general, this research is relevant for PSTs' awareness of how they learn mathematics and mathematical content through educational activities in mathematics courses, as well as their observation and evaluation of mathematics teaching in schools, and their awareness and understanding of content when planning teaching activities. Research has also focused on the interconnection between PSTs' mathematical knowledge and reflections, and the analysis of teaching situations, which they may implement in collaboration with other teachers, or independently on the basis of their own experiences (Dewey, 1998). Psychological research has also looked at teachers' subject-related, content-specific professional development through critical reflection and self-reflection (Mezirow & Taylor, 2009; Hardy, Decristan, & Klieme, 2019). The present study focuses on PSTs' knowledge of teaching in combination with their reflections on practice and the analysis of the teaching experiences of their peers, as this constitutes a

particularly important part of their own development as they form a mathematical identity. Understanding the continuous connection between the development of PSTs' knowledge of mathematics and teaching practices can provide a better understanding of the subject of mathematics, which will have a positive impact on individual competence and mathematics performance (Boaler, 2002). Moreover, PSTs who engage in positive teaching practices have been shown to achieve both academic and professional growth (Zhao & Zhang, 2017).

The opportunity to analyze the outcomes of conceptual teaching content in the practical teaching of mathematics enables PSTs to identify the relationship between practice and theoretical knowledge, as well as to construct conceptual knowledge. In particular, the ability of PSTs to evaluate the outcome of their practice may contribute to theoretical knowledge, or, as Shulman (1987) put it, that "the development of scientific knowledge for teaching as a diverse disciplinary knowledge and its interrelations as a framework for a knowledge base for teaching". In PSTs' mathematics education, the study of mathematics knowledge bases for teaching plays an important role, specifically in understanding the relationship between theoretical knowledge and teaching practice, as well as PSTs' learning of mathematics for teaching. This mathematics knowledge is key to the teaching of mathematics and for current research discussions about mathematics knowledge base and its impact on PSTs' learning to teach mathematics (Darling-Hammond & Bransford, 2005; Hordern & Tatto, 2018). The importance of mathematical concepts and their conceptual meaning related to PSTs' knowledge of mathematics has been highlighted by several researchers (Hine, 2015; Askew, 2020; Aguilar & Telese, 2018; Shulman, 2019; Weingarden, 2024) and in the context of STEM education (Alrwaished, 2024).

Leikin and Zazkis (2010) have claimed that the learning of mathematical concepts is a result of a subject mathematics content knowledge and an epistemological knowledge component. Empirical evidence of the connection between these components has led to a learning discourse on PSTs' mathematics education in which subject matter knowledge and content knowledge can serve as a logical starting point for understanding the planning of teaching activities, conceptual structures and teaching content (Anderson & Clark, 2012). As the formation of these concepts is considered crucial for teaching mathematics, researchers have indicated there is a positive relationship between subject mathematics knowledge and the quality of teaching (Ball, Lubienski, & Mewborn, 2001; Karlsson & Kilborn, 2021). This provides prospective teachers with an understanding of what to teach and how to teach it, while creating a context that supports student learning, continuity, and conceptual progression. PSTs' conceptual learning of mathematical concepts and concepts for teaching mathematics, as well as the transfer between them, is created on the basis of PSTs' knowledge of their future profession as teachers. This also includes conceptual learning specifically about subject mathematics in terms of the meaning of mathematical concepts, and the connection between mathematical concepts and mathematical teaching and learning (Jakobsen, Thames, & Ribeiro, 2013; Norton, 2019). This is an important part of PSTs' preparation, so that they can teach mathematics in a way that develops the knowledge their students need to understand mathematics and its link to science. This study examines and has an important focus on PSTs' learning of subject mathematics that deals with conceptual components and meaning regarding Shulman's theory of substantive and syntactic the structure of subject mathematics knowledge.

This study is a follow-up of previous research about PSTs' preparation for teaching mathematics (Karlsson & Kilborn, 2023a; 2024a; 2024b). The purpose of the study is to analyze PSTs' mathematics knowledge base and the meaning of conceptual development in their learning process related to substantive mathematics knowledge and syntactic mathematics knowledge, especially the interplay and shift between them. The study also

addresses the interplay between the activities of practice-based PSTs' training practice and their impact on the development of substantive and syntactic knowledge. In general, the study investigates PSTs' learning of profession-specific knowledge for teaching mathematics in order to achieve an in-depth understanding of the development of professional skills for teaching mathematics. The study includes an entire section on PSTs' conceptual learning of mathematics for teaching in advance.

3. THEORETICAL CONCEPTUAL FRAMEWORK

The theoretical conceptual framework refers to the conceptualization of teachers' content knowledge for teaching, as defined by Shulman (1986, 1987). Ball, Thames, and Phelps (2008) have described pedagogical content knowledge and subject mathematics knowledge as a theoretical issue. In terms of skills and competencies for teaching, PSTs' content knowledge leads to professional prosperity and expertise through theoretical study and practical experience. To underline the significance of teachers' mathematical knowledge and the quality of (future) teaching, as well as its relationship to pedagogical content knowledge, subject mathematics knowledge and subject-specific content knowledge have been defined as categories for the development of a knowledge base (Shulman, 1986), in both theoretical terms and in the context of teaching practice. A mathematics knowledge base is intended to differentiate between knowledge of mathematics as a subject discipline (procedural meaning) and knowledge of mathematics and its application in teaching and learning (what is created through conceptual meaning) (Goulding, Rowland, & Barber, 2002). A knowledge base comprises two primary parts: definition and significance, and two kinds of knowledge, substantive (SUB) and syntactic (SYN). In theory, comparing these parts provides a conceptual overview of how mathematics should be understood and how it should be taught (Askew, 2020). SUB and SYN knowledge are important components of PSTs' mathematics subject matter knowledge in conjunction with their pedagogical content knowledge (Shulman, 1987; Zaslavsky, 2008; Venkat & Askew, 2018). Researchers argue that teaching mathematics is no easy task, and that preparing PSTs to teach mathematics is a complex process that requires careful thought and preparation. The development of PSTs' professional knowledge of teaching mathematics is tied to their knowledge of fundamental mathematics and its application via explorative, classroom-based experiences. In terms of SUB and SYN contexts, acquiring knowledge of mathematics means that PSTs learn the general principles for the construction of subject mathematics, that is, "knowing that" (SUB knowledge) and how they can organize teaching mathematics content (SYN knowledge) according to Turner-Bisset (1999). In a substantive sense, mathematics focuses on mathematical facts (e.g., mathematical structures, concepts and methods) and their relationship to the subject of mathematics, as well as essential properties and the relationships between facts, mathematical structures and concepts. Insofar as it requires epistemic knowledge, syntactic knowledge is about how mathematical structures and concepts originate from mathematical ideas. Syntactic knowledge has been developed throughout history and in different cultural contexts. SYN knowledge provides the foundation for knowledge about what and how to teach mathematics and for the development of teaching experience.

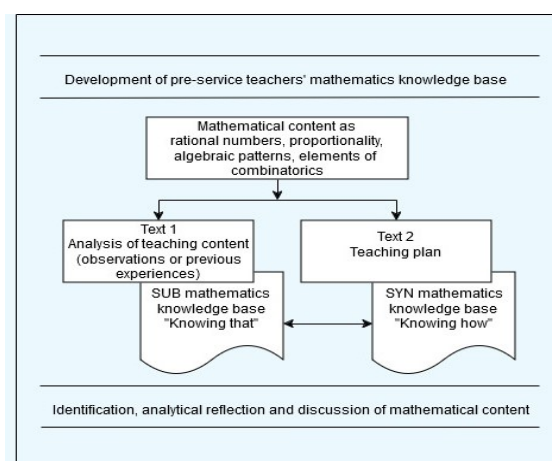
This study focuses on the structure of PSTs' substantive (SUB) and syntactic (SYN) knowledge, as this is fundamental to questions concerning what PSTs need to learn in order to effectively teach mathematics. The mathematical content that is crucial for this study includes algebraic patterns, rational numbers (fractions), proportionality, and elements of combinatorics. This is currently taught in mathematics courses.

4. METHODOLOGICAL DESIGN

4.1. Context and Participants

This study looks at substantive and syntactic knowledge in relation to primary school mathematics education in a course for pre-service K–3 teachers (Advanced Mathematics Development) and a course for PSTs of grades 4–6 (Mathematics 4). Both courses are bachelor' level programs. The study focuses on the PSTs' individual work, such as written analyses of observations and their design of a teaching plan. To track the development of the mathematics knowledge base of PSTs, the following conceptual chart has been used (Figure 1).

Figure 1.
PSTs' mathematics knowledge base.



Both courses were conducted in semester 6 of two primary school teacher education programs in the 2023 academic year. In both programs, most of the participants were female. Both courses lasted for five weeks, and the participants had no other courses during this period.

Pre-service K–3 teachers had four days of teaching practice, comprising observations and the analysis of teaching content. After the period of practicum, the PSTs were given two weeks to produce a written analysis of their observations. At the end of the course, they presented their detailed plans for teaching mathematics-specific content. The mathematical content the teachers could choose comprised algebraic patterns, rational numbers, proportionality, and basic combinatorics. For Text 2, the PSTs were asked to develop a design and mathematical content for a teaching plan. The mathematical content for Text 1 and Text 2 did not need to be identical.

The course for the grades 4–6 program did not include a special practicum component (period of practicum in school). Instead, the student teachers used their experiences from observations during an earlier period of practicum in school (part of a school-based training course). At the end of the course, the PSTs were asked to produce two written analyses (Text 1 and Text 2) (see Figure 1). The 4–6 student teachers could choose from the same crucial mathematical content as in the K–3 course. The PSTs from the K–3 and 4–6 programs differed in terms of their initial learning conditions, whether they had direct

access to practicum work, and the amount of time allocated to complete Text 1. Special attention was paid to the fundamental differences and similarities between these learning conditions. The key component of the study was the analysis of the PSTs' development of substantive and syntactic knowledge, as well as the relationship between them (see Figure 1).

4.2. Data Collection and Analysis

The data include anonymized copies of the Text 1 and Text 2 assignments for individual student teachers: 20 PSTs' assignments from the K–3 program and 25 assignments from the grades 4–6 program (Corbin & Strauss, 2008). These data were analyzed using a conceptual knowledge base with both substantive and syntactic components in order to examine how the PSTs described knowledge in the substantive sense of “knowing that” (i.e., mathematical facts and concepts in Text 1) and in the syntactical sense of “knowing how,” (i.e., the systematic analysis and evaluation of concepts in terms of teaching, argumentation, and logical ability in Text 2). The first component addressed the PSTs' analysis of teaching content, and the second component addressed their design of a teaching plan using a subject-specific mathematics content, see Figure 1.

4.3. Methods for Analyzing the Content in Text 1 and Text 2

It is important to note that the evaluation and analysis of written content were related to the PSTs' knowledge base. In Text 1, this was related to SUB structure and in Text 2, to SYN structure. The qualitative analysis of Texts 1 and 2 uses three criteria related to Marton and Booth (1997). For Text 1 (Analysis of teaching content), the following qualitative criteria were used: (1) *identification* of mathematical content; (2) *analytical reflection* on structure and the meaning of content; and (3) *analytical discussion* about how the observed teaching content could be developed. In addition to these three criteria, four new categories have been used: (1) understanding of instructions; (2) use of relevant theoretical discourse from course books (literature) and lectures in order to identify, analytically reflect, and discuss the observed teaching content; (2) correct mathematical language; (3) correct mathematical terminology; and (4) logical sense and clear structure in the written text. For the analysis of Text 2 (Design of a teaching plan), the following criteria were used: (1) *choice of* mathematical content concerning course content; (2) *analytical reflection* on the teaching plan, including two mathematical activities within the chosen mathematical content; and (3) *analytical discussion* about the connections between the teaching plan and the learning outcomes (more specifically, the concept and essential properties of the concept). For Text 2 course books, the school curriculum and textbooks were used for the respective grades. In such the same the above categories (1–4) were used.

4.4. Mathematical Content

The crucial course contents for Text 1 and Text 2 are rational numbers, algebraic patterns, proportionality, and elements of combinatorics. In this context, mathematical concepts are considered in relation to the theoretical discourse about “how to teach” and by “breaking down” the concepts in the teaching. The concept of rational numbers is related to sub-constructs (essential properties of fractions) as part-whole, part of a number, fractions as a number, fractions as a ratio, and the connection between the essential properties of a fraction with ratio, proportion, and proportionality, as well as operations with rational

numbers. Algebraic patterns are related to the multiplication table and its structure and problem-solving tasks (Karlsson & Kilborn, 2023b). Proportionality is related to the proportionality constant, proportional relationships, proportionality, and problem-solving tasks. The elements of combinatorics are related to combinations and permutations and their representations via diagrams. The content was carefully presented in the course book (Karlsson & Kilborn, 2015) and during the lectures.

5. RESEARCH FINDINGS

5.1. Substantive Knowledge and Text 1

Overall, clear elements of a substantive component were identified in the assignments (Text 1) for 12 pre-service K–3 teachers and 10 pre-service grade 4–6 teachers. Among these, it was apparent that during the analytical processes, it was difficult for the PSTs in both groups to distinguish between conceptual facts and teaching and facts related to the subject of mathematics. Also, the PSTs had difficulty organizing a sequential description and analyzing concepts and struggled in the identification, reflection and discussion (SUB component) of mathematical concepts. Even though the observed teaching included elements of combinatorics or algebraic patterns, the written analysis tended to focus on limited, fact-based conceptual issues, primarily on natural numbers and counting with natural numbers. These results, which are described above, were found in the assignments (Text 1) for both the K–3 and grade 4–6 PSTs. It was apparent that it was difficult for PSTs to convey their own knowledge of subject mathematics (SUB component) to the observed teaching practice. Instead, they focused on the content they knew best, such as natural numbers and other easily understood content. They had different time frames for producing Text 1, but the differences had no discernable effect on the quality of their texts. The K–3 PSTs had two weeks to produce Text 1 (based on direct observations), and the grade 4–6 PSTs had five weeks to work on Text 1. Both groups faced the same challenges in demonstrating sufficient (substantive) knowledge. Most PSTs did not use the content from the relevant course books or lectures. It appears that they tried to address the teaching content but with no theoretical basis. This indicates that PSTs perceive teaching practice as a separate event with no connection to the content structure. It was interesting to note that the participants believed that their analysis/understanding of mathematics teaching in primary school did not require theoretical knowledge. They described the teaching of mathematical content from their own experiences and understanding of what teaching should look like and it was difficult for them to shift from practice to theory and vice versa. The results of the study show that the PSTs in both groups had poor content knowledge related to the SUB component, which was exacerbated by the participants' negative perceptions of theory and literature.

5.2. Syntactic Knowledge and Text 2

The analysis of Text 2, which comprised PSTs' detailed teaching plans, indicated a positive change in the achievement of SUB knowledge in both groups. 18 out of 20 K–3 and 16 out of 20 grade 4–6 PSTs were able to provide a theoretical account of a SUB component and showed a tendency to try to overlap SUB and SYN components in their texts. During the course, most of the participants learned conceptually toward transformative SUB-based thinking and were able to incorporate this into their teaching plan. However, it was still challenging for them to systematically assimilate the content in a teaching situation. It was difficult for them to change perspective, that is, to change the

perspective of their analysis from a student's perspective to teacher's perspective and take on the role of a teacher. This led to them making a statement about mathematical facts, rather than the construction of a teaching plan. It was clear that SUB knowledge serves to enhance the qualitative development of SYN knowledge. These findings indicate that subject-specific content knowledge is key to the ability of PSTs to construct syntactic knowledge.

6. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

While this study reveals several key findings, some limitations should be taken into account. Firstly, because of the theoretical design of the study and the use of qualitative analysis, no general conclusions can be drawn. Secondly, as there only a limited number of participants, any further studies should use more participants. Thirdly, because the study did not examine the participants attitudes, behaviors and relationship to the subject of mathematics, or their participants' previous studies during their teacher education program, this should be taken into account in future studies as it may have a strong impact on the SUB and SYN knowledge of PSTs. Finally, the present study focuses on a mathematics knowledge base and a hidden process behind participants' learning of mathematics for teaching in the framework of the current study. Thus, the findings of the present study are not generalizable and are tied to the specific context of the study.

This research has highlighted the importance of the relationship between prospective teachers' preparation, mathematics knowledge base, and ability to learn and teach mathematics.

Further research is needed to clarify the optimal relationship between the development of theoretical knowledge of mathematics for teaching and the students' period of practicum, with a focus on the advantages and disadvantages. Research should also follow up on the quality of PSTs' mathematical preparation and promote innovative mathematical instruction for future teacher education.

7. CONCLUSION

The purpose of this study was to analyze PSTs' knowledge base and its development in relation to substantive subject matter knowledge and syntactic subject matter knowledge. Some interesting findings emerged from the study. Firstly, mathematical content such as algebraic patterns, rational numbers, and elements of combinatorics requires a certain level of conceptual knowledge in order to be assimilated by PSTs. Their performance was poor when it came to algebraic patterns and rational numbers. In their analysis, they tended to rely on the mathematical content they could recall from lectures and seminars, rather than using it combinatorically. In short, PSTs were able to replicate, but not create something of their own. At the same time, combinatorics was the best-described learning field for PSTs. Our hypothesis is that they learned combinatorics through experimentation (visualization), whereas algebraic patterns and rational numbers are more abstract forms of mathematics. This finding also indicates that PSTs' knowledge and early learning of mathematics still has a strong impact on their learning of both components, but it has a greater impact on the SYN component. The study highlights the importance of paying more attention to how PSTs learn mathematics for teaching. This is consistent with previous studies (Shulman, 1987; Turner-Bisset, 1999; Zaslavsky, 2008; Venkat & Askew, 2018), where researchers have emphasized that the process of preparing PSTs to teach mathematics is complex and requires proper forethought and preparation.

In summary, the results of this study reveal that student teachers face challenges in learning and applying mathematical concepts, as well as in their development of SUB knowledge. This means that in education programs for mathematics teachers, more attention should be given to developing PSTs' knowledge base in the form of SUB knowledge and the transformation from a SUB to a SYN mindset, as well as the impact of this transformation on student teachers' learning of mathematics for teaching (Goulding et al., 2002). The present study provides a broader understanding of the process by which student teachers learn mathematics for teaching. The results clearly show that the challenges related to the substantive and syntactic components of teachers' knowledge base need further investigation. The study also illustrates that the learning ability of PSTs is highly dependent on theoretical knowledge and that the school-based period of practicum was not sufficient for developing such a knowledge base.

The benefits of the empirical findings are that they led to new knowledge and a deeper understanding of PSTs' learning of mathematical concepts through two learning processes (SUB and SYN), as well as the relationship and shift between these processes. Thus, this research is very timely and raises some important points for future research as well as a broad range of theoretical and practical knowledge for teacher education.

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Chapter # 10

ASSESSMENT OF NUMERICAL COGNITION IN BRAZILIAN PRESCHOOLERS

Elaboration and Study Pilot

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ABSTRACT

During the preschool years, the main difficulty that can predict the risk of mathematical difficulties is the delay in the ability to learn quantities associated with number words and Arabic numerals. Objective: to assess numerical cognition for Brazilian preschoolers aged 2 years to 5 years and 11 months old. Methods: Based on a literature review, mathematical skills were selected to evaluate numerical cognition. A pilot study was conducted to verify the applicability of the developed instrument in 74 Brazilian preschoolers (44 boys) from public municipal early childhood education in the city of São Paulo, Brazil, distributed in the following age groups: Group I: 15 preschoolers, aged 2 years to 2 years and 11 months old; Group II: 18 preschoolers, aged between 3 years and 3 years and 11 months old; Group III: 19 preschoolers, aged between 4 years and 4 years to 11 months old; and Group IV: 22 preschoolers, aged between 5 years and 5 years to 11 months old. Developing an instrument to assess numerical cognition in preschoolers can contribute to developing logical-mathematical reasoning in these children, helping teachers develop activities and games that teach basic numerical, contributing to future gains in mathematics learning.

Keywords: numerosity, mathematical skills, dyscalculia, early childhood, early childhood education.

1. INTRODUCTION

Few studies in the literature investigate mathematical development in children in early childhood (Gersten, Jordan, & Flojo, 2005). In Brazil, this literature is still non-existent. Therefore, the present study proposes to develop an instrument to assess numerical cognition for preschoolers aged between 2 and 5 based on theoretical foundations. Understanding the process of learning mathematics, its difficulties and, consequently, school failure, is a major challenge for all professionals involved in the field of education. The main concern of this work was to promote a better understanding of the difficulties in learning mathematics and the mental processes involved in this learning process in the early years, as well as a clearer and more descriptive diagnosis of the problems in this learning process.

Children's numerical and spatial skills play a critical role in mathematical development, so it is essential to understand the potential impact that age can have on these skills and their relationships with learning (Moeller et al., 2012), as they can be helpful for the development of educational interventions (Geary, Hoard, Byrd-Craven, Nugent, & Numtee, 2007).

Braeuning, Ribner, Moeller, and Blair (2020) state that basic numerical skills acquired before school entry significantly predict later mathematical and educational achievement (Parsons & Bynner, 2005; Duncan et al., 2007; Jordan, Kaplan, Ramineni, & Locuniak, 2009,

Jordan, Glutting, & Ramineni, 2010). These skills are often summarized under the broad early numeracy construct (Aunio & Niemivirta, 2010), an umbrella term that encompasses several skills such as verbal counting, knowledge of numerical symbols, recognizing quantities, discerning numerical patterns, comparing numerical magnitudes, and manipulating quantities (Raghubar & Barnes, 2017).

According to Chu et al. (2019), it is unclear whether children's early foundation for mathematical development rests on an evolved number sense or their understanding of number words and numerals (De Smedt, Noël, Gilmore, & Ansari, 2013; Geary & vanMarle, 2016). Number sense is supported by the approximate number system (ANS) that allows people and other animals to determine the relative quantity of two object collections and perhaps perform basic arithmetic operations on these representations (Feigenson, Dehaene, & Spelke, 2004; Gallistel & Gelman, 2000; Geary, Berch, & Mann Koepke, 2015).

2. BACKGROUND

Chu et al. (2019) stated that performance on ANS measures is correlated with concurrent and prospective mathematical performance (Bonny & Lourenco, 2013; Libertus, Feigenson, & Halberda, 2013; Starr, Libertus, & Brannon, 2013), and severe ANS deficits may underlie mathematical learning disabilities in some children (Piazza et al., 2010). Although a relationship between ANS acuity and mathematical performance has been confirmed in several meta-analyses (Chen & Li, 2014; Fazio, Bailey, Thompson, & Siegler, 2014; Schneider et al., 2017), the proposal that this is a causal relation is debated (Carey, Shusterman, Haward, & Distefano, 2017; De Smedt et al., 2013; Fuhs & McNeil, 2013; Rousselle & Noël, 2007).

Some authors have developed models that focus on children's initial conceptual understanding of number words and numerals (Chu, vanMarle, & Geary, 2015; vanMarle, Chu, Li, & Geary, 2014) and their later fluency in accessing the corresponding magnitudes (Holloway & Ansari, 2009; Rousselle & Noël, 2007). Children's memorization of number words, the standard counting sequence, and their use of this sequence to enumerate object collections provide the first foothold in symbolic mathematics, but by themselves do not indicate a conceptual understanding of number symbols (Fuson, 1988; Gelman & Gallistel, 1978).

According to Chu et al. (2019), children's first major conceptual insight comes with their understanding of the quantities represented by number words, that is, their cardinal values (Carey, 2004; Le Corre & Carey, 2007; Wynn, 1992). Children's progression on a standard cardinality measure and give-a-number explain this concept's unfolding development (Wynn, 1992). In the give-a-number measure, children are asked to provide n objects from a pile of objects. According to Chu et al. (2019), most 3-year-olds can provide an object when asked to do so but provide random quantities for other number words and are referred to as knowing one. Over the next 1 or 2 years, children will learn the quantities associated with two, three, and four, referred to as knowing two, three, and four, respectively (Le Corre & Carey, 2007). Sometime after this point, children understand that each number word represents a unique quantity and that each successive number is one more than the previous number. Children are then considered to know cardinal principles, although it will take several years to understand that each subsequent number is $n + 1$ (Cheung, Rubenson, & Barner, 2017; Le Corre & Carey, 2007; Wynn, 1990).

The age at which children achieve cardinal principle status predicts their later numerical and arithmetic skills, controlling for other factors (Chu, vanMarle, Rouder, & Geary, 2018; Geary et al., 2018; Spaepen, Gunderson, Gibson, Goldin-Meadow, & Levine, 2018). Thus, if a fundamental quantitative deficit precedes the emergence of mathematical learning disability, then this deficit likely involves low ANS acuity, delayed understanding of cardinality, or delayed learning of basic numerical skills that precede children's understanding of cardinality. The latter would include knowledge of the counting sequence and the use of this sequence to enumerate items' collections (Fuson, 1988; Gelman & Gallistel, 1978).

For most children, according to Raghubar & Barnes (2017), the acquisition and mastery of early mathematical skills occur spontaneously through activities at home and other experiences in the child's everyday environment (LeFevre et al., 2009). However, this is not the case for all children. For example, children from low-socioeconomic families typically demonstrate less developed numerical knowledge during the preschool and kindergarten years than their middle-income peers (Griffin, Case, & Siegler, 1995; Jordan, Huttenlocher, & Levine, 1994; Starkey, Klein, & Wakeley, 2004), which has been associated with exposure to significantly fewer and less complex everyday numerical activities and experiences (Blevins-Knabe & Musin-Miller, 1996).

According to Raghubar & Barnes (2017), children with learning difficulties related to specific neurodevelopmental disorders or other developmental factors struggle to acquire informal mathematical knowledge. Consequently, children with low numerical skills at the beginning of early childhood education, regardless of the source of this lack of mathematical knowledge, are at high risk of low performance in mathematics in the early years of elementary school (Jordan et al., 2009).

Based on the above, this study hypothesizes that developing an instrument to assess numerical cognition in preschoolers can contribute to the identification of possible difficulties. This study aimed to develop an instrument to evaluate numerical cognition for preschoolers for children aged 2 to 5 years and 11 months old and apply it in a pilot study.

3. METHOD

This study was approved by the Research Ethics Committee of the Faculty of Philosophy and Sciences of the São Paulo State University "Júlio de Mesquita Filho" - FFC/UNESP - Marília-SP, under number 6,138,570 and was divided into phase 1 – Bibliographic survey and preparation of the assessment of numerical cognition for preschoolers and phase 2 – Pilot study.

The guardians who agreed to the assessment of the child/adolescent read and signed the Free and Informed Consent Form. All children included in the study signed the Assent Form.

3.1. Phase 1: Development of the Instrument

Based on the national and international bibliographic survey on numerical cognition assessment skills for the age group of 2 to 5 years and 11 months old, a protocol was developed containing the following abilities: subitizing, knowledge of numerals, counting, one-to-one correspondence, perception of magnitude, cardinality, comparison, measurement and approximation and estimation (the latter only for the age group of 4 years and 11 months to 5 years and 11 months old). In addition to consulting the national and international literature, the activities described in the National Common Curricular Base (BNCC) in the Early Childhood Education division (BRASIL, 2017) were also consulted so that the

assessment activities developed in this phase of the study are aligned with the guidelines of this National Literacy Plan.

The bibliographic survey was carried out using the following databases: Scielo Scopus, PubMed, and Web of Science to search for studies on numerical cognition assessment instruments in preschoolers. The bibliographic survey was conducted at the Investigation Learning Disabilities Laboratory (LIDA) of the Speech Therapy Department of the Faculty of Philosophy and Sciences of the São Paulo State University “Júlio de Mesquita Filho- FFC/UNESP- Marília- SP.”

Table 1 presents the research results on numerical knowledge in Early Childhood Education, adapted for developing the numerical cognition assessment instrument for preschoolers.

Table 1.
Description of intervention programs with preschoolers described in the literature.

Authors	Year	Objectives	Skills worked on	Age Group
Geary, D. C., van Marle, K., Chu, F. W., Rouder, J., Hoard, M. K., & Nugent, L.	2018	Identify preschool quantitative skills that predict children's knowledge of the school number system.	Identifying the age at which children first understand cardinality, early quantitative skills, number recognition and counting list knowledge, ordinal comparison, and discrete quantity discrimination	3 years and 10 months to 6 years and 9 months old
Sarnecka, B. W., & Lee, M. D.	2009	Analyze the performance pattern of errors when the child is asked for a certain number of objects.	Intransitive counting (reciting the list of number words up to “ten”) and transitive counting of arrays of 5 and 10 objects. Giving a requested number of objects	2 years to 4 years old
Sarnecka, B. W., & Carey, S.	2008	Explore children's understanding of how the direction and unit of numerical change are represented by moving forward or backward through the list of numerals	Determine which numerals the child knows the exact meanings of. Measure the child's knowledge of the numeral up to “ten.” Measure the child's ability to mark objects in one-to-one correspondence with the list of numbers. Investigate the child's responses to a question about how many follow a standard counting by an adult.	2 years and 10 months to 4 years and 3 months old

Authors	Year	Objectives	Skills worked on	Age Group
Le Corre, M., & Carey, S.	2007	Analyze children's performance in a verbal numerical estimation task.	Give a requested number of objects Counting Estimating	2 years to 5 years old
Jordan, N. C., Kaplan, D., Nabors Oláh, L., & Locuniak, M. N.	2006	Longitudinal investigation of children at risk of difficulties in mathematics for the development of number sense in Early Childhood Education	Measures of number sense: Counting skills, number recognition, number knowledge, nonverbal calculation, narrative problems, number combinations, estimation, and number patterns.	5 years old

3.2. Phase 2: Pilot Study

The study included 74 Brazilian preschoolers (44 boys and 30 girls) from public municipal early childhood education in the city of São Paulo, distributed in the following age groups: Group I (GI): composed of 15 preschoolers aged 2 years to 2 years and 11 months old; Group II (GII): composed of 18 preschoolers, aged 3 years to 3 years and 11 months old; (GIII): composed of 19 preschoolers, aged 4 years to 4 years to 11 months old; and (GIV): composed of 22 preschoolers, aged 5 years to 5 years to 11 months old.

All preschoolers underwent the assessment of numerical cognition for preschoolers. The numerical tasks were designed to be applied as games to maintain attention. Short breaks were provided between tasks, as necessary. The researcher assessed the participants individually in a room within the school environment.

Non-parametric statistical tests were used to analyze the results since the normality of the primary outcome quantitative variables was tested using the Kolmogorov-Smirnov test ($N < 100$), and it was concluded that there is no guaranteed normal distribution. A significant level of 0.05 (5%) was adopted.

4. RESULTS

The analyses began with an Intragroup comparison. For each group, the Obtained and Expected results were compared, starting with the quantitative ones, using the Wilcoxon test.

Table 2.
Intragroup Comparison for Quantitative Factors.

			Average	Median	Standard Deviation	Q1	Q3	IQR	N	IC	P-value
Verbal counting	Group 1	Obtained	2,04	1	2,96	0	2,75	2,75	26	1,14	0,001*
		Expected	5,00	5	0,00	5	5	0	26	- x -	
	Group 2	Obtained	5,12	4	4,56	1	10	9	49	1,28	<0,001*
		Expected	10,00	10	0,00	10	10	0	49	- x -	
	Group 3	Obtained	13,20	10	13,48	5	17,5	12,5	71	3,13	0,119
		Expected	10,00	10	0,00	10	10	0	71	- x -	
	Group 4	Obtained	26,22	20	19,51	10	38	28	73	4,48	<0,001*
		Expected	10,00	10	0,00	10	10	0	73	- x -	
Sequence counting	Group 1	Obtained	2,31	0	3,22	0	4,5	4,5	26	1,24	0,001*
		Expected	5,00	5	0,00	5	5	0	26	- x -	
	Group 2	Obtained	4,53	3	4,01	1	10	9	49	1,12	<0,001*
		Expected	10,00	10	0,00	10	10	0	49	- x -	
	Group 3	Obtained	7,65	10	3,25	5	10	5	71	0,76	<0,001*
		Expected	10,00	10	0,00	10	10	0	71	- x -	
	Group 4	Obtained	9,56	10	1,65	10	10	0	73	0,38	0,042*
		Expected	10,00	10	0,00	10	10	0	73	- x -	
One-to-one correspondence tokens	Group 1	Obtained	3,50	1,5	3,67	1	5	4	26	1,41	<0,001*
		Expected	10,00	10	0,00	10	10	0	26	- x -	
	Group 2	Obtained	5,78	5	4,06	2	10	8	49	1,14	<0,001*
		Expected	10,00	10	0,00	10	10	0	49	- x -	
	Group 3	Obtained	8,15	10	3,05	5	10	5	71	0,71	<0,001*
		Expected	10,00	10	0,00	10	10	0	71	- x -	
	Group 4	Obtained	9,75	10	1,21	10	10	0	73	0,28	0,109
		Expected	10,00	10	0,00	10	10	0	73	- x -	

It was found that for Verbal Count, there is a difference between Obtained and Expected for Groups 1, 2, and 4 (P-value of 0.001, <0.001, and <0.001, respectively), and in Group 3, we have no statistical difference with an average of 13.20 for Obtained against 10.00 for Expected (p-value = 0.119).

Sequence Count is significant in the four groups, where the average for Obtained was consistently below Expected, as in Group 1, with an average of 2.31 for Obtained and 5.00 for Expected (p-value = 0.001).

Finally, in “One-to-one correspondence of tokens,” it was verified that the significance between Obtained and Expected occurred again in groups 1, 2, and 3. In Group 1, for example, the average for Obtained was 3.53 against 10.0 for Expected (P-value = 0.002).

The obtained and expected results were compared, but the Chi-Square test determined the distribution of qualitative factors (percentages or prevalences).

Table 3.
Intragroup Comparison for Distribution of Qualitative Factors.

			Expected		Obtained		P- Value
			N	%	N	%	
Cardinality 5	Group 1	Correct	0	0,0%	3	11,5%	0,074
		Incorrect	26	100,0%	23	88,5%	
	Group 2	Correct	49	100,0%	15	30,6%	<0,001*
		Incorrect	0	0,0%	34	69,4%	
	Group 3	Correct	71	100,0%	50	70,4%	<0,001*
		Incorrect	0	0,0%	21	29,6%	
	Group 4	Correct	73	100,0%	61	83,6%	<0,001*
		Incorrect	0	0,0%	12	16,4%	
Cardinality 7	Group 1	Correct	0	0,0%	1	3,8%	0,313
		Incorrect	26	100,0%	25	96,2%	
	Group 2	Correct	49	100,0%	6	12,2%	<0,001*
		Incorrect	0	0,0%	43	87,8%	
	Group 3	Correct	71	100,0%	37	52,1%	<0,001*
		Incorrect	0	0,0%	34	47,9%	
	Group 4	Correct	73	100,0%	61	83,6%	<0,001*
		Incorrect	0	0,0%	12	16,4%	
Cardinality enumeration counting 5	Group 1	Correct	26	100,0%	10	38,5%	<0,001*
		Incorrect	0	0,0%	16	61,5%	
	Group 2	Correct	49	100,0%	27	55,1%	<0,001*
		Incorrect	0	0,0%	22	44,9%	
	Group 3	Correct	71	100,0%	61	85,9%	<0,001*
		Incorrect	0	0,0%	10	14,1%	
	Group 4	Correct	73	100,0%	69	94,5%	0,043*
		Incorrect	0	0,0%	4	5,5%	
Cardinality enumeration counting 7	Group 1	Correct	0	0,0%	4	15,4%	0,037*
		Incorrect	26	100,0%	22	84,6%	
	Group 2	Correct	49	100,0%	14	28,6%	<0,001*
		Incorrect	0	0,0%	35	71,4%	
	Group 3	Correct	71	100,0%	48	67,6%	<0,001*
		Incorrect	0	0,0%	23	32,4%	
	Group 4	Correct	73	100,0%	66	90,4%	0,007*
		Incorrect	0	0,0%	7	9,6%	
Cardinality colored tokens	Group 1	Knowledgeable	0	0,0%	0	0,0%	- x -
		Not Knowledgeable	26	100,0%	26	100,0%	
	Group 2	Knowledgeable	49	100,0%	7	14,3%	<0,001*
		Not Knowledgeable	0	0,0%	42	85,7%	
	Group 3	Knowledgeable	71	100,0%	38	53,5%	<0,001*
		Not Knowledgeable	0	0,0%	33	46,5%	

	Group 4	Knowledgeable	73	100,0%	64	87,7%	0,002*
		Not Knowledgeable	0	0,0%	9	12,3%	
Cardinality last word	Group 1	Knowledgeable	0	0,0%	1	3,8%	0,313
		Not Knowledgeable	26	100,0%	25	96,2%	
	Group 2	Knowledgeable	49	100,0%	9	18,4%	<0,001*
		Not Knowledgeable	0	0,0%	40	81,6%	
	Group 3	Knowledgeable	71	100,0%	38	53,5%	<0,001*
		Not Knowledgeable	0	0,0%	33	46,5%	
	Group 4	Knowledgeable	73	100,0%	60	82,2%	<0,001*
		Not Knowledgeable	0	0,0%	13	17,8%	
Data comparison	Group 1	Correct	26	100,0%	15	57,7%	<0,001*
		Incorrect	0	0,0%	11	42,3%	
	Group 2	Correct	49	100,0%	33	67,3%	<0,001*
		Incorrect	0	0,0%	16	32,7%	
	Group 3	Correct	71	100,0%	63	88,7%	0,004*
		Incorrect	0	0,0%	8	11,3%	
	Group 4	Correct	73	100,0%	72	98,6%	0,316
		Incorrect	0	0,0%	1	1,4%	
Domino comparison	Group 1	Correct	26	100,0%	16	61,5%	<0,001*
		Incorrect	0	0,0%	10	38,5%	
	Group 2	Correct	49	100,0%	37	75,5%	<0,001*
		Incorrect	0	0,0%	12	24,5%	
	Group 3	Correct	71	100,0%	63	88,7%	0,004*
		Incorrect	0	0,0%	8	11,3%	
	Group 4	Correct	73	100,0%	72	98,6%	0,316
		Incorrect	0	0,0%	1	1,4%	
Comparison of different objects	Group 1	Correct	26	100,0%	2	7,7%	<0,001*
		Incorrect	0	0,0%	24	92,3%	
	Group 2	Correct	49	100,0%	22	44,9%	<0,001*
		Incorrect	0	0,0%	27	55,1%	
	Group 3	Correct	71	100,0%	47	66,2%	<0,001*
		Incorrect	0	0,0%	24	33,8%	
	Group 4	Correct	73	100,0%	60	82,2%	<0,001*
		Incorrect	0	0,0%	13	17,8%	
Comparison of similar objects	Group 1	Correct	26	100,0%	8	30,8%	<0,001*
		Incorrect	0	0,0%	18	69,2%	
	Group 2	Correct	49	100,0%	30	61,2%	<0,001*
		Incorrect	0	0,0%	19	38,8%	
	Group 3	Correct	71	100,0%	49	69,0%	<0,001*
		Incorrect	0	0,0%	22	31,0%	
	Group 4	Correct	73	100,0%	64	87,7%	0,002*
		Incorrect	0	0,0%	9	12,3%	

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One-to-one correspondence between each student and their book	Group 1	Correct	26	100,0%	26	100,0%	- x -
		Incorrect	0	0,0%	0	0,0%	
	Group 2	Correct	49	100,0%	48	98,0%	0,315
		Incorrect	0	0,0%	1	2,0%	
	Group 3	Correct	71	100,0%	71	100,0%	- x -
		Incorrect	0	0,0%	0	0,0%	
	Group 4	Correct	73	100,0%	73	100,0%	- x -
		Incorrect	0	0,0%	0	0,0%	
Domino measurement	Group 1	Correct	26	100,0%	20	76,9%	0,009*
		Incorrect	0	0,0%	6	23,1%	
	Group 2	Correct	49	100,0%	35	71,4%	<0,001*
		Incorrect	0	0,0%	14	28,6%	
	Group 3	Correct	71	100,0%	67	94,4%	0,042*
		Incorrect	0	0,0%	4	5,6%	
	Group 4	Correct	73	100,0%	71	97,3%	0,154
		Incorrect	0	0,0%	2	2,7%	
Elephant/Dog Measurement	Group 1	Correct	26	100,0%	22	84,6%	0,037*
		Incorrect	0	0,0%	4	15,4%	
	Group 2	Correct	49	100,0%	42	85,7%	0,006*
		Incorrect	0	0,0%	7	14,3%	
	Group 3	Correct	71	100,0%	66	93,0%	0,023*
		Incorrect	0	0,0%	5	7,0%	
	Group 4	Correct	73	100,0%	73	100,0%	- x -
		Incorrect	0	0,0%	0	0,0%	
Ice/fire Measurement	Group 1	Correct	26	100,0%	15	57,7%	<0,001*
		Incorrect	0	0,0%	11	42,3%	
	Group 2	Correct	49	100,0%	36	73,5%	<0,001*
		Incorrect	0	0,0%	13	26,5%	
	Group 3	Correct	71	100,0%	63	88,7%	0,004*
		Incorrect	0	0,0%	8	11,3%	
	Group 4	Correct	73	100,0%	72	98,6%	0,316
		Incorrect	0	0,0%	1	1,4%	
Magnitude perception 1 by 2	Group 1	Correct	26	100,0%	13	50,0%	<0,001*
		Incorrect	0	0,0%	13	50,0%	
	Group 2	Correct	49	100,0%	38	77,6%	<0,001*
		Incorrect	0	0,0%	11	22,4%	
	Group 3	Correct	71	100,0%	58	81,7%	<0,001*
		Incorrect	0	0,0%	13	18,3%	
	Group 4	Correct	73	100,0%	71	97,3%	0,154
		Incorrect	0	0,0%	2	2,7%	
Magnitude perception 2 by 3	Group 1	Correct	26	100,0%	10	38,5%	<0,001*
		Incorrect	0	0,0%	16	61,5%	
	Group 2	Correct	49	100,0%	31	63,3%	<0,001*
		Incorrect	0	0,0%	18	36,7%	
	Group 3	Correct	71	100,0%	59	83,1%	<0,001*
		Incorrect	0	0,0%	12	16,9%	

		Incorrect	0	0,0%	12	16,9%	
		Correct	73	100,0%	69	94,5%	
Magnitude perception 3 by 4	Group 4	Incorrect	0	0,0%	4	5,5%	0,043*
		Correct	26	100,0%	10	38,5%	
	Group 1	Incorrect	0	0,0%	16	61,5%	<0,001*
		Correct	49	100,0%	25	51,0%	
	Group 2	Incorrect	0	0,0%	24	49,0%	<0,001*
		Correct	71	100,0%	54	76,1%	
	Group 3	Incorrect	0	0,0%	17	23,9%	<0,001*
		Correct	73	100,0%	64	87,7%	
	Group 4	Incorrect	0	0,0%	9	12,3%	0,002*
		Correct	26	100,0%	14	53,8%	
	Group 1	Incorrect	0	0,0%	12	46,2%	<0,001*
		Correct	49	100,0%	29	59,2%	
Magnitude perception 4 by 5	Group 2	Incorrect	0	0,0%	20	40,8%	<0,001*
		Correct	71	100,0%	55	77,5%	
	Group 3	Incorrect	0	0,0%	16	22,5%	<0,001*
		Correct	73	100,0%	56	76,7%	
	Group 4	Incorrect	0	0,0%	17	23,3%	<0,001*
		Correct	26	100,0%	10	38,5%	
	Group 1	Incorrect	0	0,0%	16	61,5%	<0,001*
		Correct	49	100,0%	22	44,9%	
	Group 2	Incorrect	0	0,0%	27	55,1%	<0,001*
		Correct	71	100,0%	45	63,4%	
	Group 3	Incorrect	0	0,0%	26	36,6%	<0,001*
		Correct	73	100,0%	55	75,3%	
Magnitude perception 5 by 6	Group 4	Incorrect	0	0,0%	18	24,7%	<0,001*
		Correct	26	100,0%	9	34,6%	
	Group 1	Incorrect	0	0,0%	17	65,4%	<0,001*
		Correct	49	100,0%	25	51,0%	
	Group 2	Incorrect	0	0,0%	24	49,0%	<0,001*
		Correct	71	100,0%	52	73,2%	
	Group 3	Incorrect	0	0,0%	19	26,8%	<0,001*
		Correct	73	100,0%	59	80,8%	
	Group 4	Incorrect	0	0,0%	14	19,2%	<0,001*
		Correct	26	100,0%	5	19,2%	
	Group 1	Incorrect	0	0,0%	21	80,8%	<0,001*
		Correct	49	100,0%	26	53,1%	
Data subitizing	Group 2	Incorrect	0	0,0%	23	46,9%	<0,001*
		Correct	71	100,0%	55	77,5%	
	Group 3	Incorrect	0	0,0%	16	22,5%	<0,001*
		Correct	73	100,0%	68	93,2%	
	Group 4	Incorrect	0	0,0%	5	6,8%	0,023*
		Correct	26	100,0%	9	34,6%	
Domino subitizing	Group 1	Incorrect	0	0,0%	17	65,4%	<0,001*
		Correct	26	100,0%	9	34,6%	

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Subitizing sticks	Group 2	Correct	49	100,0%	27	55,1%	<0,001*
		Incorrect	0	0,0%	22	44,9%	
	Group 3	Correct	71	100,0%	53	74,6%	<0,001*
		Incorrect	0	0,0%	18	25,4%	
	Group 4	Correct	73	100,0%	69	94,5%	0,043*
		Incorrect	0	0,0%	4	5,5%	
	Group 1	Correct	26	100,0%	7	26,9%	<0,001*
		Incorrect	0	0,0%	19	73,1%	
	Group 2	Correct	49	100,0%	29	59,2%	<0,001*
		Incorrect	0	0,0%	20	40,8%	
	Group 3	Correct	71	100,0%	57	80,3%	<0,001*
		Incorrect	0	0,0%	14	19,7%	
One-to-one correspondence of ten objects	Group 1	Correct with Help	0	0,0%	7	26,9%	0,004*
		Correct without Help	26	100,0%	3	11,5%	<0,001*
		Incorrect	0	0,0%	16	61,5%	<0,001*
	Group 2	Correct with Help	0	0,0%	9	18,4%	0,002*
		Correct without Help	49	100,0%	16	32,7%	<0,001*
		Incorrect	0	0,0%	24	49,0%	<0,001*
	Group 3	Correct with Help	0	0,0%	16	22,5%	<0,001*
		Correct without Help	71	100,0%	41	57,7%	<0,001*
		Incorrect	0	0,0%	14	19,7%	<0,001*
	Group 4	Correct with Help	0	0,0%	3	4,1%	0,080
		Correct without Help	73	100,0%	68	93,2%	0,023*
		Incorrect	0	0,0%	2	2,7%	0,154
Numeral knowledge	Group 1	Not Numeric	0	0,0%	7	26,9%	0,004*
		One	0	0,0%	4	15,4%	0,037*
		Two	0	0,0%	9	34,6%	<0,001*
		Three	26	100,0%	4	15,4%	<0,001*
		Four	0	0,0%	2	7,7%	0,149
		>4	0	0,0%	0	0,0%	- x -
	Group 2	Not Numeric	0	0,0%	5	10,2%	0,022*
		One	0	0,0%	6	12,2%	0,011*
		Two	0	0,0%	11	22,4%	<0,001*
		Three	0	0,0%	13	26,5%	<0,001*
		Four	49	100,0%	9	18,4%	<0,001*
		>4	0	0,0%	5	10,2%	0,022*
	Group 3	Not Numeric	0	0,0%	0	0,0%	- x -
		One	0	0,0%	0	0,0%	- x -
		Two	0	0,0%	7	9,9%	0,007*

Numeral knowledge (Groups 4)	Group 4	Three	0	0,0%	10	14,1%	0,001*
		Four	0	0,0%	18	25,4%	<0,001*
		>4	71	100,0%	36	50,7%	<0,001*
		Not Numeric	0	0,0%	0	0,0%	- x -
		One	0	0,0%	1	1,4%	0,316
		Two	0	0,0%	3	4,1%	0,080
		Three	0	0,0%	2	2,7%	0,154
		Four	0	0,0%	6	8,2%	0,012*
		>4	73	100,0%	61	83,6%	<0,001*
	Dinosaurs	Correct	73	100,0%	40	54,8%	<0,001*
		Incorrect	0	0,0%	33	45,2%	
	Tokens <10	Correct	73	100,0%	44	60,3%	<0,001*
		Incorrect	0	0,0%	29	39,7%	
	Tokens >30	Correct	73	100,0%	44	60,3%	<0,001*
		Incorrect	0	0,0%	29	39,7%	
	Points 15	Correct	73	100,0%	14	19,2%	<0,001*
		Incorrect	0	0,0%	59	80,8%	
	Points 25	Correct	73	100,0%	18	24,7%	<0,001*
		Incorrect	0	0,0%	55	75,3%	
	Points 3	Correct	73	100,0%	70	95,9%	0,080
		Incorrect	0	0,0%	3	4,1%	
	Points 35	Correct	73	100,0%	12	16,4%	<0,001*
		Incorrect	0	0,0%	61	83,6%	
	Points 8	Correct	73	100,0%	46	63,0%	<0,001*
		Incorrect	0	0,0%	27	37,0%	

It was concluded that there is a statistical difference between the Obtained and Expected for several factors in all groups. However, in addition to the significant results, we can also talk about the non-significant ones, as they show that the group had an Obtained result considered statistically equal to the Expected one. An example is the result in “Cardinality 7,” where in Group 1, the Correct rate was 3.8%, statistically equal to the 0.0% of the Expected one (p-value = 0.313).

Another example to mention is the result of the “Domino comparison,” where it was observed that in Group 4, the rate between Obtained and Expected are statistically equal, as for the correct one, which was 98.6% in the Obtained against 100% in the Expected one (p-value = 0.316). For this same parameter in Group 3, the Correct rate was 88.7%, statistically different from the 100% of the Expected one (p-value = 0.004).

In addition to the intragroup analyses, intergroup results were performed, where the four groups were compared for the results obtained, starting with the quantitative factors using the Kruskal-Wallis test.

Table 4.
Intergroup Comparison for Quantitative Factors.

		Average	Median	Standard Deviation	Q1	Q3	IQ R	N	IC	P-Value
Verbal counting	Group 1	2,04	1	2,96	0	2,75	2,75	26	1,14	<0,001*
	Group 2	5,12	4	4,56	1	10	9	49	1,28	
	Group 3	13,20	10	13,48	5	17,5	12,5	71	3,13	
	Group 4	26,22	20	19,51	10	38	28	73	4,48	
Sequence count	Group 1	2,31	0	3,22	0	4,5	4,5	26	1,24	<0,001*
	Group 2	4,53	3	4,01	1	10	9	49	1,12	
	Group 3	7,65	10	3,25	5	10	5	71	0,76	
	Group 4	9,56	10	1,65	10	10	0	73	0,38	
One-to-one correspondence tokens	Group 1	3,50	1,5	3,67	1	5	4	26	1,41	<0,001*
	Group 2	5,78	5	4,06	2	10	8	49	1,14	
	Group 3	8,15	10	3,05	5	10	5	71	0,71	
	Group 4	9,75	10	1,21	10	10	0	73	0,28	

Table 5.
P-values of the post-hoc groups in the quantitative factors.

		Group 1	Group 2	Group 3
Verbal counting	Group 2	0,002*		
	Group 3	<0,001*	<0,001*	
	Group 4	<0,001*	<0,001*	<0,001*
Sequence count	Group 2	0,008*		
	Group 3	<0,001*	<0,001*	
	Group 4	<0,001*	<0,001*	<0,001*
One-to-one correspondence tokens	Group 2	0,016*		
	Group 3	<0,001*	0,001*	
	Group 4	<0,001*	<0,001*	<0,001*

Since there were four groups, all the groups were first compared together (Kruskal-Wallis test in Table 4), and it was concluded from the p-values in Table 4 that there was a statistical difference between the groups in the three factors analyzed. Thus, it was necessary to specify the comparison between the groups in pairs to determine precisely which groups the difference occurs between. Therefore, only these p-values were presented in Table 5 (using the Mann-Whitney test), where it is enough to cross the row with the column to find the p-value between the necessary groups. In general, there is a difference between all the groups in the three parameters.

For example, the result for Verbal Counting is an average of 2.04 in G1, 5.12 in G2, 13.20 in G3, and 26.22 in G4. Analyzing the p-values in the post-hoc table (Table 5), we concluded that there is a difference between all the groups.

Finally, the groups were compared for the distribution of qualitative factors by analyzing the percentages using the Chi-Square test.

Table 6.
Intergroup Comparison for the Distribution of Qualitative Factors.

		Group 1		Group 2		Group 3		Group 4		P-Value
		N	%	N	%	N	%	N	%	
Cardinality 5	Correct	3	11,5%	15	30,6%	50	70,4%	61	83,6%	<0,001*
	Incorrect	23	88,5%	34	69,4%	21	29,6%	12	16,4%	
Cardinality 7	Correct	1	3,8%	6	12,2%	37	52,1%	61	83,6%	<0,001*
	Incorrect	25	96,2%	43	87,8%	34	47,9%	12	16,4%	
Cardinality enumeration counting 5	Correct	10	38,5%	27	55,1%	61	85,9%	69	94,5%	<0,001*
	Incorrect	16	61,5%	22	44,9%	10	14,1%	4	5,5%	
Cardinality enumeration counting 7	Correct	4	15,4%	14	28,6%	48	67,6%	66	90,4%	<0,001*
	Incorrect	22	84,6%	35	71,4%	23	32,4%	7	9,6%	
Cardinality colored tokens	Knowledgeable	0	0,0%	7	14,3%	38	53,5%	64	87,7%	<0,001*
	Not Knowledgeable	26	100,0%	42	85,7%	33	46,5%	9	12,3%	
Cardinality last word	Knowledgeable	1	3,8%	9	18,4%	38	53,5%	60	82,2%	<0,001*
	Not Knowledgeable	25	96,2%	40	81,6%	33	46,5%	13	17,8%	
Data comparison	Correct	15	57,7%	33	67,3%	63	88,7%	72	98,6%	<0,001*
	Incorrect	11	42,3%	16	32,7%	8	11,3%	1	1,4%	
Domino comparison	Correct	16	61,5%	37	75,5%	63	88,7%	72	98,6%	0,001*
	Incorrect	10	38,5%	12	24,5%	8	11,3%	1	1,4%	
Comparison of different objects	Correct	2	7,7%	22	44,9%	47	66,2%	60	82,2%	<0,001*
	Incorrect	24	92,3%	27	55,1%	24	33,8%	13	17,8%	
Comparison of similar objects	Correct	8	30,8%	30	61,2%	49	69,0%	64	87,7%	<0,001*
	Incorrect	18	69,2%	19	38,8%	22	31,0%	9	12,3%	
One-to-one correspondence between each student and their book	Correct	26	100,0%	48	98,0%	71	100,0%	73	100,0%	0,369
	Incorrect	0	0,0%	1	2,0%	0	0,0%	0	0,0%	
Domino measurement	Correct	20	76,9%	35	71,4%	67	94,4%	71	97,3%	<0,001*
	Incorrect	6	23,1%	14	28,6%	4	5,6%	2	2,7%	
Elephant/Dog Measurement	Correct	22	84,6%	42	85,7%	66	93,0%	73	100,0%	0,110
	Incorrect	4	15,4%	7	14,3%	5	7,0%	0	0,0%	
Ice/fire measurement	Correct	15	57,7%	36	73,5%	63	88,7%	72	98,6%	<0,001*
	Incorrect	11	42,3%	13	26,5%	8	11,3%	1	1,4%	
Magnitude perception 1 by 2	Correct	13	50,0%	38	77,6%	58	81,7%	71	97,3%	<0,001*
	Incorrect	13	50,0%	11	22,4%	13	18,3%	2	2,7%	

Magnitude perception 2 by 3	Correct	10	38,5%	31	63,3%	59	83,1%	69	94,5%	<0,001*
	Incorrect	16	61,5%	18	36,7%	12	16,9%	4	5,5%	
Magnitude perception 3 by 4	Correct	10	38,5%	25	51,0%	54	76,1%	64	87,7%	<0,001*
	Incorrect	16	61,5%	24	49,0%	17	23,9%	9	12,3%	
Magnitude perception 4 by 5	Correct	14	53,8%	29	59,2%	55	77,5%	56	76,7%	0,045*
	Incorrect	12	46,2%	20	40,8%	16	22,5%	17	23,3%	
Magnitude perception 5 by 6	Correct	10	38,5%	22	44,9%	45	63,4%	55	75,3%	0,016*
	Incorrect	16	61,5%	27	55,1%	26	36,6%	18	24,7%	
Magnitude perception 6 by 7	Correct	9	34,6%	25	51,0%	52	73,2%	59	80,8%	<0,001*
	Incorrect	17	65,4%	24	49,0%	19	26,8%	14	19,2%	
Data subitizing	Correct	5	19,2%	26	53,1%	55	77,5%	68	93,2%	<0,001*
	Incorrect	21	80,8%	23	46,9%	16	22,5%	5	6,8%	
Domino subitizing	Correct	9	34,6%	27	55,1%	53	74,6%	69	94,5%	<0,001*
	Incorrect	17	65,4%	22	44,9%	18	25,4%	4	5,5%	
Subitizing sticks	Correct	7	26,9%	29	59,2%	57	80,3%	65	89,0%	<0,001*
	Incorrect	19	73,1%	20	40,8%	14	19,7%	8	11,0%	

In this study, we found that preschoolers in the 4 groups performed similarly in object comparison, measurement, and magnitude perception skills, showing that these skills did not differentiate the groups.

5. FUTURE RESEARCH DIRECTIONS

Based on the results of this study, a study of the applicability of the assessment procedure developed in phase 1 will be conducted to establish reference standards for the procedure, which will be used to identify Brazilian preschool children at risk for mathematical problems early on.

According to Gersten et al. (2005), the development of number sense can be improved by formal or informal instruction before school entry. At least in 5- and 6-year-old children, the two components of number sense (counting/simple calculation and magnitude sense/use of mental number line) are not well linked. Creating such relationships from the beginning may be critical for developing proficiency in mathematics. Children who have not acquired these relationships probably require an intervention that builds them. Therefore, more research investigating children's numerical knowledge in Early Childhood Education for early identification and intervention is welcome.

6. CONCLUSION/DISCUSSION

The results of this study showed that, based on the literature, an instrument to assess numerical cognitive skills for Brazilian preschoolers aged 2 to 5 years old could be developed.

The ability to subitize small quantities, discern numerical patterns, compare numerical magnitudes and estimate quantities, and count and perform simple numerical transformations are critical elements of number sense in young children (Berch, 2005). Most children develop number sense before formal instruction (Ginsburg & Golbeck, 2004).

One-to-one correspondence appears around two years old, independently of learning the sequence of counting words. According to Butterworth (2005), children can give each person a piece of candy at two years old. In our study, in the one-to-one correspondence activity, children from all groups could give each child a book when asked to do so. However, within the same activity, in counting up to 10 tokens and up to 10 dinosaurs, these activities were more assertive from group 2 onwards. The pilot study showed that verbal counting, sequential counting, and one-to-one correspondence were sensitive skills in characterizing preschoolers' performance according to age group.

According to Geary et al. (2018), children's initial steps in symbolic mathematics include learning the sequence of number words (counting list), recognizing numerals, and counting objects (Geary & vanMarle, 2016; Gelman & Gallistel, 1978; Wynn, 1990). However, this can occur without conceptualizing the symbol or procedure. These activities gain meaning from children's understanding of the cardinal value of number words. Still, the path to this knowledge is long and complex, as illustrated by the task of cardinality-colored tokens (Sarnecka & Carey, 2008).

Children were asked to provide an x number of tokens from a stack of tokens to the researcher. "One" knower provided one token when asked to do so, but random quantities for other number words. "One" knower status is usually achieved between 2 and 3 years old, as was found in our research. It takes children 3 to 6 months to learn the quantities associated with each successive number word up to four. Sometime later, children conceptualize that each number word represents a unique quantity and that successive numbers in their counting list are one more than the previous number (Le Corre & Carey, 2007).

The results of this study are consistent with Jordan, Glutting, and Ramineni (2008), who suggested that interrelated skills involving numbers and operations develop between the ages of 3 and 6, such as subitizing, identifying quantities without counting, counting items in a set of at least five, knowing that the final word of the count indicates how many are in the set.

Developing an instrument to assess numerical cognition in preschoolers can help develop logical-mathematical reasoning in these children, assisting teachers in developing activities and games that teach basic numerical, spatial, geometric, measurement, and statistical concepts, contributing to future gains in mathematics learning.

This study showed that a procedure to assess numerical cognitive skills for Brazilian preschoolers could be developed, and it could also indicate which skills differentiated the groups by age group.

The relatively brief numerical cognition assessment protocol is a valid and powerful measure that can predict which children will likely have problems learning mathematics at the beginning of school. According to Jordan et al. (2010), number sense is an intermediate skill that can be achieved through early instruction (Ginsburg, Lee, & Boyd, 2008). Number sense, which involves interrelated concepts of counting, numerical knowledge, and operations, as presented in our battery, promises to guide the development of early intervention programs.

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Chapter # 11

ABSENCE-PRESENCE IN THE PRODUCTION OF ‘GREEN’ SCHOOLSAPES

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ABSTRACT

Schoolscapes are increasingly involved in the production of ‘green’ artefacts, installations, and activities. However, schoolscape discourse rarely features design processes and negotiations related to school ‘greening’. What does it mean for schools to become ‘green’? This chapter offers a critical examination of school ‘greening’ beyond its pedagogical purpose, particularly through tracing logics underlying production and consumption of tree-based installations in government primary schools of suburban Mumbai. Participant observation, and go-along conversations with school members reveals an image of a ‘green’ school, as an intense version of reality. The schools bear ‘presence’ of trees in absence of actual trees in or around their campus, through crafting site-specific displays. The discussion articulates how ‘green’ schoolscape is projected as a prospective remedy for many issues. The desirability of the hyperverdant projections seems to rest on the seemingly liberating, yet normative discourse of ‘mending’. Analysis of schoolscape production concludes that, despite their apparently subversive character within educational conventions, the ‘green’ imaginings inadvertently reinforce the very norms they seek to challenge. This could result in school members negotiating paradoxical expectations. Implications are discussed with regard to new ways of thinking about schoolscape design research in the context of Environment Education.

Keywords: green image, absence presence, schoolscape.

1. INTRODUCTION

Schools are becoming sites for ‘green’ artefacts and activities to support the implementation of Environment Education (EE) pedagogy. What does it mean for schools to become ‘green’? What are the conditions within which ‘greening’ unfolds? Existing research in school practice of ‘greening’ tends to foreclose inquiry into its diverse narratives. Majority of scholarly research on schoolsapes, primarily as linguistic landscapes, is limited to depictions of environmental crises (Ardhian, Setiawati, Sukmawan, Setiawan, & Purwaningrum, 2020), ecological symbolism (Setiawati, Sukmawan, Ardian, Setiawan, & Purwaningrum, 2020), environmental issues (Mendes, 2020) and so on. In contrast, the chapter seeks to uncover ‘greening’ through the school members’ perspectives, mainly teachers, and the complexities of community, institutional, governmental, and social contexts influencing them. Schoolscape refers to the images, humans, other-than-humans, symbols, written language, placement in time and space (Shohamy & Waksman, 2009, 314) as well as oral language (Brown, 2012) in schools. Extending these definitions, for the current inquiry, schoolscape is not considered as an object or setting, but as a verb – schoolscape. The phenomenological stance (Pope, 2006) especially encourages observing and examining the performative nature of how individuals construct the schoolscape as an ongoing process.

Schoolscapes in our study refers to school displays and related social practices in production of murals, installations, and exhibits. Our examination of schoolscape production shall reveal that, despite the ostensibly subversive nature of ‘greening’ initiatives within conventions of the formal education system, the schoolscapes seldom diverge from prevailing ideologies; rather, they inadvertently reinforce the very norms they aim to contest in leaning towards a hyperverdant image. In proposing the term hyperverdance, we draw on the concept of hyperreality (Baudrillard, 1994), that manifests through carefully curated performative spaces where ‘greening’ unfolds’.

2. BACKGROUND

Schoolscapes could have varying goals – moral, didactic, pedagogical, wellbeing-oriented and so on. The current work reveals absent presences underlying various objectives for which ‘greening’ is pursued, through three installation displays in Mumbai schools. The Primary school system of the Mumbai Municipal Corporation in Maharashtra, India, is the largest urban primary school system in Asia, with over 0.47 million students from low-income families receiving free education across eight different instructional media (Juneja, 2001). A municipal school building in an urban setting often consists of four or five stories, featuring a flagstone or concrete courtyard. Incorporating environmental issues into public school curricula continues to pose a challenge (Kim & Fortner, 2006) due to lack of skilled staff, infrastructural limitations, and various socio-economic forces shaping school members’ lives. Greater Mumbai is divided into seven administrative zones, each comprising three to five wards designated alphabetically. This chapter, based on data from two schools, is part of a larger study for which field work was initiated in June 2022 for a year. Access to a total of four schools from the S and N ward was secured upon due consent from official channels.

3. OBJECTIVES

The research objective is to investigate the purpose behind the installations in the school ground; the treatment towards tree-based installations in schools; and various discourses, performativities, and absent presences characterising these installations. While schoolscape studies have focused on examining language ideologies (Brown, 2012), patterns of language related to climate change (Solihah & Anjaniputra, 2024), and temporalisation in schoolscapes (Aya & Savski, 2023); the current inquiry is more interested in the production of material displays inside the school building premises. The term ‘green’ for this study is not defined based on theoretical literature, rather it is mentioned as it colloquially emerged in teacher-talk.

4. RESEARCH DESIGN

The data for this study is based on research in two government primary schools in suburban Mumbai. Data from go-along conversations with six teachers and two principals is included in this chapter. All the teachers were from primary grades, and taught Environmental Studies (EVS) in addition to teaching their subject specialisations. Field-notes from participant observation were analysed alongside go-along conversations. The teachers’ quotes are labelled as T1, T2 and so on, while the school principals’ quotes are labelled as P1 and P2. The three installations or displays in the school grounds that this chapter considers are an India-map structure around a tree stump, a pencil-shape carved from a dead tree, and tree-plantation ceremony set-up.

5. METHODS

The study is inspired by ethnographic approaches under the constructivist paradigm (Denzin & Lincoln, 1994), through which this inquiry seeks to understand the school members' perspectives to discover their subjective realities. The researcher recorded go-along conversations with school members as well as conducted observations that were documented through audio-recording, journaling, and note-taking. Go-alongs happened 2-3 times per week, and were not continuous but broken into segments based on the teachers' availability. A total of 405 hours of data was collected across a year-long study period with four schools. This chapter is based on the data from two of those schools. Walking and conversing do not yield a traditional interrogative interaction as in interviews, rather offers a possibility for members to engage in more spontaneous dialogue and movement (Anderson, 2004). The study employs the guided approach (Kinney, 2017), which involves participant-led go-alongs, wherein the participant assumes the role of the expert guide, leading the researcher through specific regions in the school. The researcher lingered around while listening to members discuss something and go about their day. Field notes contained systematic documentation of the observations and conversations.

Since EE is not considered a core topic in school curriculum, school members hesitate to share their experiences regarding it. Further, teacher lives are complex, and surrounded with various societal and other forces. Methods such as interviews, focus groups, video documentation, and diary studies have limitations such as uneven participation of teachers, gatekeeping by school officials, time and other pressures, and ethical concerns. Hence, the go-along approach emerged as an appropriate way to build rapport with school members and learn about the schoolscape practice with least amount of interference or interruption in the school members' schedules. The researcher accompanied school members to various areas of the school and also became a participant-observer during school activities. Key questions considered by the researcher during the go-alongs were: How did the idea of the display come to be? What is the process of thinking about and preparing the displays? When and why were certain concerns thought of as relevant? How do the activities and displays imagine school members and their roles? How and what kind of negotiations emerge in the framing of the displays?

Teachers often returned to the same location multiple times during walks with the researcher to add to their narrative of conducting activities or producing displays. No time restriction was imposed on the go-along conversations; nonetheless, most lasted a minimum of thirty minutes, with duration solely dictated by the school members. The conversations focused on teachers' negotiations pertaining to realising 'green' displays. Conversations were conducted in Marathi, Hindi and English language. These were transcribed and translated to English before analysis. Data analysis was done through inductive coding until data saturation was achieved. In the first phase, key aspects of activities which the teachers described and discussed among each other were coded and labelled. The subsequent phases were conducted as open-coding to generate sub-themes based on teachers' ideas, feelings, and negotiations related to schoolscape. For instance, episodes from the data were analysed by noting specific sections from discussions and field notes which concerned notions around school identity and location. Further analysis revealed that these were related to larger themes of how activities within public-facing portions of the schools were treated. Sections within episodes were labelled to arrive at groups of themes. For instance, a discussion between teachers around reasons to develop the map installation was tagged under "negotiating purpose".

6. KEY FINDINGS

This chapter discusses two of the broad themes emerging from the analysis: The first theme is ‘Greening’ as ‘mending’ with subthemes 1. Restorative reminder and 2. More than a school; and the second theme is ‘Green’ imaginings with subthemes 1. Inviting the outdoors and 2. Model ‘green’ appearance.

6.1. ‘Greening’ as ‘Mending’

This theme elucidates the notion of ‘mending’ expressed in school members’ discussions as part of their planning for certain installations.

6.1.1. Restorative Reminder

One of the schools has an installation in the playground area that shows the map of India contoured on the ground, lined with stones and bricks. It has a tree stump in the middle. This installation was being conceived at the idea level and its rough form was in place on the ground. So, a vision was in place and ‘in use’ in its temporary, rudimentary form.

The school principal mentioned that the tree stump’s placement at the ‘heart of India’ was to serve as a reminder to children and everyone else about the importance of ‘saving trees’, and ‘mending their mistakes’: (P1: “This is how humans can mend their mistakes”).

Thus, ‘greening’ of the school through such an installation is perceived as an act of ‘mending’. The school members dwelt on how to develop the installation of the India map. One of the teachers mentioned that the tree that used to be present on the patch was cut down because some electric wires were to be installed in the area and the tree’s presence was an obstacle. Another teacher said that this story was not true and that the tree had got burnt due to lightning bolts during heavy thunderstorms. Yet another teacher said that the tree had been cut as it was prone to collapsing during high winds. Production of the installation was seen as a mark of pride for the school, though there were varying perspectives on inclusion of the tree stump: (T1: “Why form a huge map around a dead tree? The tree stump is an obstruction in the centre. Instead, we can colour the stump and stick some decorations on it, bugs and butterflies may be, and make the map structure elsewhere.”), T2: “But try imagining the tree at the centre of India. The memory of the tree can also be a message for younger generations. In fact, this map could be the main attraction during Independence Day celebrations.”).

Discussions about whether the tree should be part of the installation highlights teachers’ concerns about what the overall installation’s message could be. The stump serves as more than a conventional aesthetic prop for T2. The ‘message’ is explained as an important restorative ‘reminder’ by the principal in the quote here: (P1: “The tree at the heart of India would remind everyone that it is time we made amends. It is important for the students to know about the country and keep its heritage clean and green. This map would be the pride of our school.”).

The principal’s response talks about the tree stump as both a reminder of loss and a sign to start over. As the consensus over having the tree stump at the centre of the map became prominent, there was a discussion about access to the installation as well: (T3: “We need to think of marking timings and boundaries for entry so that the structure remains protected. Else, the children might start playing inside the map structure any time during the day.”), T2: “Maybe, T1’s idea about colouring and decorating the stump can help in communicating the exclusivity of this installation. We can fence it too.”).

Children’s possible interactions with the installation posed a concern for its maintenance. While T3 and T2 were concerned about protecting the structure, the principal proposed the installation’s pedagogical purpose. Exclusivity was emphasised to create a

distinction between the map and other elements of the playground. The principal, in response to T3 and T2, presented a perceived novel-use of the stump, as in the quote here: (P1: Yes, but a teacher can sit on the stump, surrounded by children, and conduct regular storytelling sessions and lessons about seasons or crops grown in different parts of India. Such concepts will be admired by the officials and parents.”). The quotes in this theme overall show that maintenance of school identity, pedagogical goals, and commitment to reverence for national heritage emerge as functions of the installation. In contrast to T2’s idea for the map as a prominent ‘attraction’ for parents and officials visiting the school on Independence Day, P1 imagines an everyday function.

6.1.2. More Than a School

The tree is once again an absent presence in another school where the government school image must be restored through reviving a large pencil-shape carved out of a dead tree trunk. A photograph of a large pencil-installation from another school was filed in the school portfolio record which was spoken of by the principal while sharing her vision to revive their school’s installation to signify the school’s dedication to the National Literacy Mission campaign. Here we see a discussion on its upcoming plans: (P2: “Since this tree is situated near our school’s entrance, we must revive it. Let us bring back the giant pencil.” T4: “Yes, but it should not look like a regular pencil. Maybe one with wings? We already have a spare pair of wings from last year’s annual-function.”, T6: “Should we let children think of something to do with it? It will be a unique idea. It can be an eco-craft project for them. Or perhaps we can have some volunteer groups for help.”, P2: “No, no. Think more. It is in the forefront of the school building. It represents us. Our school must look like more than a school, like a place to dream big and experiment. It should feel alive, unlike other government schools!”). A mundane object such as the pencil is distanced from the layers of signs carried by this installation as it becomes a reference of itself, rather than the pencil as we know it.

Two interconnected aspects are discussed here. One is about achieving the spectacle of the pencil-tree, and the other is questioning the meaning of school itself. There is a longing to project the school as ‘more than a school’. The image of government schools was brought in as a context to further support this desire. The response by T6 was uttered in the context of a staff meeting which took place a few weeks ago, wherein there were discussions to engage children in craft work. The principal’s vision of creating ‘more than a school’ appears to contrast dominant notions associated with schools. At the same time, there is some sort of hesitation towards including children into the design process. The way the school must look is already envisioned by the school teachers and principal, as evident in the proposal to add wings and a constant emphasis on the prominent location of the installation.

6.2. ‘Green’ Imaginings

This theme further elaborates reasons for ‘greening’ installations beyond pedagogical purposes.

6.2.1. Inviting the Outdoors

Teachers discussed the issue of maintaining ‘greenery’ within the ‘map’: (T2: “How do we maintain the greenery within the map boundary?”, T1: “We do not need to. It need not be picture-perfect. Instead, we can colour the boundary stones green and erect some green-coloured wooden sticks perhaps?”, P1: “Yes. Our children and teachers can do this with whatever is available around. No need for external volunteers taking a long time to do something big and fancy. Imagine a teacher sitting on the tree stump with children sitting all around. It can be, you know, camping style.”). The feel of a camp-site and a perceived sense

of ownership is evoked by the principal in scripting teacher-student performativity (Ball, 2003) through the imagined installation plan. This description echoes the previous expression of creating something ‘more than a school’. Camp-like setting and atmosphere is visualised as a rarely found activity both in the busy city and regular school life. School thus becomes a site for staging such performances. Maintenance of ‘greenery’ was raised as an issue by T2, while T1 provided an alternative by suggesting an accessible option, that of green-coloured stones and sticks. T2’s concern to maintain the grassy-greenness of the map is contrasted with the principal’s idea of a rustic and wild feel of camping sites. One can notice aspirations to simulate something which is “out there”, inside the school.

Invigilation is an absent presence. The green-map installation is imagined as a managed space. It is proposed with specific functions in mind regardless of the occurrence of perceived external invigilation possibilities. Schoolness of the ‘green’ installation is maintained in suggestions for creating physical and temporal boundaries. Children are imagined as visitors, allowed only at certain times and for specific pedagogical purposes. They become an absent presence. The school principal – a figure of authority – while addressing a crowd of parents refers to the act of tree-memorialisation as an act of ‘repair’: (P1: “Children in cities need to reconnect with the environment and repair lost relationships ... The remnant of the tree in the middle of the map is our reminder.”).

6.2.2. Model ‘Green’ Appearance

The metaphor of ‘mending’ is re-invoked in the build up to a tree-plantation ceremony in school. In the process of curating the events of the ceremony, the tree is framed within ‘care’ scripts. Care for the school and the planet is projected in ‘caring for those who care for us’ – a piece of text written on a poster next to the spot where the first tree of the event is to be planted. Teachers made sure that they sent information about the event to the parents’ social media groups, and reminded them to keep posting photos of the event online. As such, in ‘greening’, surveillance is simulated as school members become self-governed without explicit external monitoring. The tree-plantation activity normalises displays of and reverence for specific forms of labour and codes which form another layer of absent presences, clear in the following discussion between teachers: (T1: “Do not forget to record the process of planting the tree.”, T3: “Yes. And we must remember to tell the students to colour the watering cans before the shoot begins. They have to rehearse their lines too.”, T1: “But they all are busy with stage practice. I will go paint some watering cans. Will you take care of my class until then?”, T3: “Never mind. There is less time. Let us just remember to get the bigger cans and do away the wilted pot-plants. I will paint some small ones at home, just for background decoration, like the ones the principal likes. Photos will have to be posted throughout the year anyway. They better look fresh.”).

The principal had expressed preference for a display of watering cans based on some school photos posted by other school principals on social media. Here we notice the pursuit for referring to exemplar schools to achieve a model ‘green’ appearance. In the search for a model ‘green’ appearance, data is continuously, widely, and intrapersonally captured to be later reconstructed into the exemplar-like. There is an omnipresent possibility of sharing geo-tagged images of school activities, whether carried out at school or at home. Teachers’ negotiation of their time and effort is in service of preserving the watering can as a testament to the celebratory spirit of the school people. There appears to be a preference to emphasise the ongoingness of voluntary-work over one-time event-specific labour. Paradoxically, one of the goals of such installations, which is to encourage children’s participation, as hinted at by teachers several times, remains peripheral. This is not to comment on the need, degree or quality of children’s participation; or to criticise the actions, thoughts, and behaviour of

school adults in the above examples. Rather, it is to do with how the schoolscaping activity imagines school members and the idea of the school becoming a 'green' school.

Members of the school community, including the students' parents, need not believe whether the installations could encourage participation towards environment awareness. However, they must believe or at least pretend to believe in the spectacle and even help maintain it as such, to avoid getting disturbed by potential collateral damage. The process of designing the spectacle of 'green' school necessitates compromises, yet its efficacy hinges on obscuring the remnants of what has been compromised. Tree plantation-drives tend to exude an atmosphere wherein one cannot discern that the emergence of a seemingly transformative and solutionistic endeavour, somewhere necessitates the presence of a compromise. Selective roles, appearance, and specific status of teachers, students, and other-than-humans, such as the 'wilted' pot-plants and the watering cans, emerges from the material-discursiveness of the 'greening' activities. The installation-design process seems to remodel questions of why and what should be 'cared' for and how. Negotiations towards planning the photo-friendly events as well as the everyday documentations of such activities are apparent in T3's quote, "Photos will have to be posted throughout the year anyway. They (watering cans) better look fresh". Equipments become important props to maintain the oasis-like atmosphere, and offer a laboratorial image of the school. Stewards of this oasis – the students, had to "rehearse their lines", as mentioned by T3. Thus, an intense version of reality, the hyperreal (Baudrillard, 1994) version of the school is revealed through discourses of 'care' and management leaning towards hyperverdance.

7. DISCUSSION AND CONCLUSION

In response to the research question of "what it means for schools to become 'green'," the article traces absent presences across the production process of schoolscapes. The findings challenge the common assumption that schools create 'green' installations only for pedagogical purposes. The school's identity formation is seen as an important goal alongside pedagogical aims. Through site-specific installations, schools strive to be 'at their best' as if they are under constant inspection every day. This finding resonates in some sense with that of Clapham's (2015) study wherein teacher responses suggest that inspection is present in their school regardless of the physical presence of inspectors. Performativity is integrated into the everyday life of the school system, rather than solely for exhibition-readiness. However, Clapham's study talks only in terms of performing "lesson plans". In contrast to Clapham's study, the current study articulates how the metaphor of 'mending' helps in uncovering what is perceived as in need of 'care' by the school members even beyond lesson plans, and absent presences therein. Studies of schoolscape design tend to ignore the notion of repair/mending mobilised by school members. A rare instance has noted schools positioning themselves as "carers" through the "art of display" (Thomson, Hall, & Russell, 2007, 381-400). However, the discourse of 'mending' as described in our research has not yet found focus in studies on EE schoolscapes/schoolscaping. Implication of this finding is towards accounting for socio-material tensions between perceived awareness of what constitutes 'green' schoolscaping, and actual shape of absent presences tied to field instances of schoolscaping. Schoolscape discourse seldom includes design processes and negotiations pertaining to 'greening' of schools. The chapter provided an in-depth examination of school 'greening' beyond its educational objectives, specifically by exploring the underlying logics of the production and consumption of tree-based installations in government primary schools in suburban Mumbai. The 'green' projections appear to be more real than reality, or hyperverdant. Their appeal is based on the ostensibly liberating, yet authoritative notion of

‘mending’. In essence, the study of schoolscape production shows that the ‘green’ imaginings unintentionally support the very standards they aim to question, despite their supposedly radical orientation within formal education conventions.

8. FUTURE RESEARCH DIRECTIONS

Future research could build on our redefinition of schools as social practice, and descriptions of the hyperverdant texture of EE activities, to advance existing theories of schoolscape design knowledge. In addition to the lens of absence presence, further studies could examine EE schoolscaping through engaging with ways various materials constrain or facilitate social and pedagogical encounters in ‘greening’ schools.

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Chapter # 12

A TRANSFORMATIVE INSTRUCTION MODEL AND TASK-ORIENTED LEARNING

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ABSTRACT

This study is analytical research that examines a theoretical approach to transformative pedagogy (TP) and transformative learning (TL) in order to conduct a logical deductive construction of the transformative instruction model (TI model). The study aims to enhance the understanding and effectiveness of the interplay between teaching content and learning in the form of requires for the high-quality teaching of students in the cognitive development of mathematics. It also analyzes the conditions for transformative teaching and learning in a task-oriented context. The crucial psychological outcomes focus on the domains of TP and their interpretation within the context of Mezirow's TL theory, emphasizing an instrumental, dialogic and self-reflective learning discourse, as well as meaning schemes in learning. The methodological approach is based on a systematic deductive analysis. The analytical results as a conceptualization and an analytical construction of a TI model related to transformative teaching and learning algebraic concepts. The TI model is the result of extending theoretical approaches to TP and TL, as well as logical connections to research about the formation of algebraic concepts. Benefits of the TI model is a new knowledge about an effective teaching of algebra, where students' algebra learning, and knowledge development is crucial.

Keywords: transformative mathematical instruction, transformative algebra learning, task-oriented teaching, algebraic concepts.

1. INTRODUCTION

Teachers play a crucial role in students' learning and socio-emotional development, which requires a specialized knowledge base informed by research and practical insights (Guerriero, 2017). Effective teaching, that combines expertise in mathematics with an understanding of students' perspectives, creates an engaging learning process (Schwarz & Kaiser, 2019).

Despite the established principles in school mathematics (NCTM, 2000), empirical research suggests there is a need for teachers to re-evaluate their understanding of teaching mathematics. This re-evaluation is essential for achieving a deeper understanding that correlates with improved student achievement (Ulferts, 2021). Continuous learning is closely tied to enhanced overall quality of mathematical instruction (Karpov & Haywood, 1998; Daniels, 2003).

In Sweden, recognition of teachers' pivotal contributions has led to a national professional development initiative spearheaded by the Swedish Agency for Education (2012). This initiative aims to empower teachers with a structured, research-informed approach to professional growth that emphasizes the enhancement of education quality. However, despite this initiative, Sweden faces challenges in mathematics performance

compared to other countries, as indicated by international studies (e.g., Mullis, Martin, Foy, Kelly, & Fishbein, 2020; OECD, 2023).

An acknowledgment of the central role of teaching and continuous learning among educators is essential for enhancing the overall quality of education (Ma, 1999; Ball & Bass, 2000). Moreover, empirical research underscores the need for teachers to develop their understanding of reflective teaching practice, a crucial step in effectively improving student achievement (Scheiner, Montes, Godino, Carrillo, & Pino-Fan, 2019). To address these challenges, this study explores transformative pedagogy (TP) in combination with transformative learning (TL) as a viable alternative for teachers to enhance their approach to teaching mathematics that emphasizes the ongoing significance of teachers' professional development.

2. BACKGROUND

2.1. Why the Transformative Instruction Model (TI Model)?

This section outlines five arguments for the need to construct a new model for transformative instruction (TI model) that employs TP/TL learning. This will be further explored in the next section.

Firstly, empirical evidence of teachers' mathematical knowledge related to their teaching has led to discussions on improving the quality of instruction in mathematics education. There has been much research about this topic, with various theories emerging since Shulman's (1986) work. However, empirical evidence on the connection between a teacher's mathematical knowledge and its application in instruction remains limited, as highlighted by Ronda and Adler (2019). There is a need for more theoretical and empirical studies to address this gap and provide concrete insights.

Secondly, the studies emphasize the importance of teachers' having professionally specific knowledge for teaching mathematics in order for their students to improve (Ball, Hill, & Bass, 2005). However, the exact type of knowledge needed—and whether this is just about basic skills is a complex question. At the same time the nature of teachers' specific professional knowledge in relation to their mathematical knowledge plays a crucial role in students' learning and skills development. Effective learning requires finding a balance between conceptual and procedural knowledge, with conceptual understanding being crucial for students to progress (Smith, Bill, & Raith, 2018). Research continues to discuss the nature and extent of teachers' professionally specific mathematical knowledge (e.g., Hammer & Ufer, 2003). While various studies have indicated its importance for improved student achievement, the exact type of expertise needed, whether basic or complex skills, professionally specific knowledge remains unknown (Ball et al. 2005). This ongoing research emphasizes the continuous effort to identify the optimal type of professional mathematics knowledge for fostering effective teaching and student learning.

Thirdly, as mathematics is an inherently abstract subject, it requires high-quality teaching that will benefit students' cognitive development. Here, teaching quality is critical (e.g., Carter, 2024). According to Vygotsky (1986), students' mental development depends on the interaction of a mediating agent, such as a teacher, with the learning environment. Teaching mathematical concepts in line with Vygotsky's constructivist approach (Vygotsky & Rieber, 1998) is effective when the instruction is well-structured, focused on the learning process, and involves dynamic mental collaboration between the teaching content and the students (Venkat, 2021). The "ambitious instruction" MPM model highlights the importance of students' ability to generalize in the learning process, guiding teaching structure to support the understanding of content (Venkat & Askew, 2018). Teachers' knowledge of mathematics

that is described in teaching plays a crucial role in improving students' ability to learn mathematical concepts (Brown, 2011) and their in-depth understanding of the nature of students' learning is crucial for their students to acquire mathematical skills (Venkat, Askew, Watson, & Mason, 2019). This analytical research demonstrates how teachers can organize task-oriented teaching using mediating tools, such as tasks in terms of artifacts.

Fourthly, the mathematics learning process comprises three components: (1) prior knowledge; (2) expanding prior knowledge in a new learning process; and (3) reproducing new knowledge through reasoning and reflection (Nickerson, 2012). This encapsulates the core of learning and its process components, emphasizing teaching as a tool for developing learning through content. Critical reflection and thinking are crucial for teaching and learning opportunities (Dirkx, Mezirow, & Granton, 2006), in keeping with sociocultural views on mathematics learning in the conceptual learning framework about learning activity (Zuckerman, 2003). This argument led that needs to development new instructional model is referred to as *analytical research*.

Fifthly, this widely used framework in mathematics education comprises three core aspects: task analysis, action planning, and reflection, the latter of which encompasses, for example, learners' self-evaluation and understanding of alternative viewpoints (Olina & Sullivan, 2004). Crucially, it underscores the key step in the learning process, knowing mathematics through critical reflection (Liu, 2015). More research about mathematical instruction as an interplay between teaching and learning could incorporate teachers choices and analyses of learning tasks, planning teaching based on students' learning, and reflective practice including learners' self-evaluation and understanding of alternative mathematical viewpoints (Sakai et al., 2024). TP and TL concepts serve as design frameworks, addressing content, the learning process, critical thinking, and reflection (Johnson & Olanoff, 2020).

The above-cited studies provide a conceptualization and argumentation of theory-based student-oriented teaching. They analyze student learning and emphasize a key aspect related to TL. TL highlights the importance of exploring and understanding the learning process, particularly in teaching school tasks (e.g., exercises and assignments), through modified pedagogical design. The study of TP and TL is in line with research on professional development (Mezirow, 2003), experiences, and practices (Mezirow, 1997; Fleming, 2021), as well as current students' achievements in an analytical context.

This chapter on the incorporation of TP and TL theoretical tools into the TI model includes components as addressed and related to arguments 1–5 and an appropriate understanding of the meaning of mathematical instruction that previse future of design for teaching and learning mathematics (algebra).

The purpose of this analytical study is to analyze the outcome of transformative pedagogy (TP) and transformative learning (TL) in task-oriented teaching. It presents a theoretically based model for transformative instruction (TI model) that is specifically focused on enhancing students' learning of algebra. The research questions are as follows:

RQ1: How can the relationship between transformative pedagogy (TP) and transformative learning (TL) effectively enhance teaching focused on students' learning of mathematics (TI model)?

RQ2: What aspects of a TI model should be included in an appropriate algebra-specific didactic approach for transformative teaching and learning?

The TP and TL theoretical framework proposed in this study aims to stimulate discussion on the structural aspects of task-oriented teaching, providing a conceptually grounded model for transformative instruction (the TI model).

3. THEORETICAL OUTLINES

To enhance understanding of TP, a framework is presented that serves as a comprehensive design model, guiding the development of teaching and learning outcomes across philosophical, psychological, and social dimensions (Farren, 2016). This framework involves an interplay between the components of TP and conceptual meaning. The components encompass aspects that are crucial for the development of teachers and students, including identity, beliefs and attitudes, moral-ethical values, socio-affective factors, communication, (meta)cognition, school, and society. In this context, conceptual meaning encompasses reflective practices, reflective teaching, analysis of learning, and supportive learning, and leads to the development of instruction through the transformation of teachers and students via reflection and self-reflection (Farren, 2016). In this transformative process, various forms of knowledge (both personal and subject-content-specific) interact, leading to the transfer and utilization of knowledge for solving subject-specific and social-specific problems (Chapman & Guerra, 2016).

The theoretical aspects of TP, particularly within (meta)cognition, significantly impact reflective practices and the reflective teacher, emphasizing the role of the teacher in analyzing learners' needs and fostering autonomy (Farren, 2016; Fleming, 2022). TP creates conditions for practices in which teachers' knowledge of learning significantly enhances their potential for development, leading to transformative learning experiences for their students. The development of students' mathematical reflections into interaction of metacognitive and self-regulatory requirements refers to students' learning of mathematics through reflections and mathematical reasoning (Thompson, 1996). These mathematical reflections are employed under the framework of transformative teaching through various mathematical tasks related to subject-specific content to ensure an effective and profound understanding of mathematics (Hassi & Laursen, 2015). Mathematical activities that focus on a clear learning goal related to the proper planning of tasks, teachers' evaluation of students' achievements, and reflection on the students learning process provide the necessary conditions for students learning performance (Kinard & Kozulin, 2008) and transformative learning (Adams et al., 2015).

This pedagogical approach helps in the comprehension of the key components that are intrinsic to the TP concept. In keeping with TP, teachers construct knowledge through their practices and collaboration, fostering critical reflections and intentions for self-development and improvement in teaching and learning (Luitel, 2013).

An analysis of TP using Farren's framework (2016) underscores the fact that TP models, including all designs, should incorporate an appropriate subject-specific didactic approach, particularly in mathematics education. Teachers can leverage TP domains to develop their instructional practices. Systematic instruction (Smith, Saez, & Doabler, 2018) involves intentionally designing and delivering tasks in order to develop students' mathematical knowledge towards achieving specific learning outcomes and individual cognitive development. A response to RQ1 regarding the TP concept emphasizes a focus on phenomena such as knowing, reflective teaching, reflective practice, knowledge of learning, content knowledge, acts of reflections, and self-reflection. The key point in TP pedagogy' is that teachers' content knowledge is continuously developed through pedagogical reflections and reasoning regarding the reconstruction of the teaching experience, planning, and adapting teaching with regard to students' learning (Johnson & Olanoff, 2020).

For a deeper understanding of active teaching that could be beneficial to students' learning of mathematics, a follow-up TP with a theoretical analysis of TL theory will provide additional insights and knowledge about mathematical instruction and one time more

knowledge for transformative teaching. This means that the knowledge and learning process could be more successfully mastered to enhance the understanding of transformative pedagogy, specifically related to the transformative learning of mathematics actions and the practice of learning.

This analysis enhances the understanding of TP, specifically in terms of TL actions and learning practices. The interpretation and development of the TP framework using the TL approach highlighted in this study underlines the conceptual elements for the development of mathematical instruction with regard to content-based knowledge transformation and students constructing of mathematical knowledge.

4. THEORETICAL EXPANSION THROUGH THE TL APPROACH

In expanding upon the TP theoretical framework, Mezirow's learning-oriented TL theory serves as the starting point for this study (Mezirow, 1985). Of particular interest are the various types of task-oriented learning, including instrumental, dialogic, and self-reflective learning (Figure 1). In instrumental task-oriented learning, learners seek the best ways to grasp a concept. Dialogic learning explores the optimal time and place for learning, and self-reflective learning questions the purpose of acquiring content.

These learning processes lead to transformation through three types of learning known as "meaning schemes." In the first "meaning scheme" (leaning within meaning schemes, see Figure 1) process, learners expand upon, complete, and repeat what they have already learned (prior knowledge). This means a conceptual systematization and expansion of students' prior knowledge that has relevance for learning a new mathematical content. The second "meaning scheme" (learning new meaning schemes) process relates to the organizing of students' learning of new content. The third "meaning scheme" (learning through meaning schemes) process is learning by generalizing new mathematical content through task-oriented context. The transformative teaching in this fazes moving to teachers' analysis and systematization of students' mathematical learning achievements, to create written documentation in order to use it for the future planning of teaching. The crucial key in the documentation is the students' learning, challenges and misconceptions that are identified through the redefinition of these challenges and misconceptions. Transformative teaching and learning occur through task-oriented mathematical content and students' critical self-reflection supported by teaching (Kitchenham, 2008; Baumgartner, 2012).

The conceptual transfer from the first to the third "meaning scheme" process depends on the types of learning, such as instrumental, dialogic and self-reflective. Instrumental type of learning is main connected to students' learning from a procedural perspective and is particularly impacted by the teachers' step –by –step instructions. The significance of instrumental learning is the limited space it offers for learners' own reflections, explanation, and mathematical reasoning. According to Mezirow (2008), dialogic learning is another type of learning and extends instrumental task-oriented learning. This is a key focus on students' verbalization, reflections and mathematical reasoning. Dialogic type of learning in a mathematical context concern students' active verbalizing of methods or concept outcomes as discussed with their peers (Taylor & Cranton, 2012). The conceptualization of self-reflective learning in the TL framework plays a key role in students' reflective learning by critical thinking, and subject-specific reflections (Weimer, 2013).

The TL framework describes conceptual meaning as different kinds of reflection components associated with three types of learning processes ("meaning schemes"). The components are content, process and premise reflection that led to straightforward and profound knowledge transformation (see Figure 1). In analyzing the TL theoretical

framework be clear significant of follow main theoretical points for transformative teaching and learning as types of learning and task-oriented learning inclusive reflection components and it's considered to develop an optimal conceptual model for transformative instruction.

5. ANALYTICAL FINDINGS: TRANSFORMATIVE INSTRUCTION, TI MODEL

Analytical tracking of the relationship between TP and TL theories leads to a logical consequence for effectively enhancing transformative teaching focused on transformative students' learning of mathematics in a task-oriented context. How can the relationship between transformative pedagogy theory (TP) and transformative learning theory (TL) effectively enhance teaching that is focused on students' learning of mathematics (RQ1), as depicted in Figure 1?

Figure 1.
Transformative mathematical instruction model (TI model).

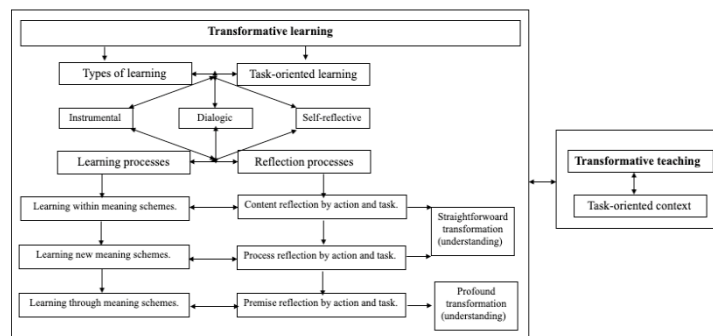


Figure 1 illustrates the development of a theoretical framework for TP concerning transformative task-oriented teaching designed as a TI model for transformative mathematical instruction through the conceptual significance of TL regarding psychological positions for learners' transformative learning. The TI context also includes TP perspectives and emphasizes profound, reciprocal transformations for both teachers and students, with reflection as a key aspect of self-reflection and reflective teaching practices. According to the TI model, the development of teachers' effective practice (teaching mathematics) depends on understanding the major constituents of transformative teaching with a focus on the learners' learning, specifically the constituents of the TI model. The transformation learning process is illustrated in the TI model as the relationship between teaching subject-activities-content (types of learning) and learning processes (meaning schemes) (Figure 1). The orientation to learning is an important conceptual point in the TI model and highlights its multifaceted nature, with transformation resulting from continuity (from prior knowledge to the generalization and application of knowledge) and the connection between the three types of learning. The TI model (Figure 1) demonstrates how teachers can organize task-oriented learning at both straightforward and more ambitious levels, in order to enhance the students' knowledge and understanding. The connection between the TI model (Figure 1) and mathematics-specific-content supports teachers in their practice, emphasizing the value of pedagogical design to mathematics education—subject content and learning.

The starting point for expanding and developing the TI theoretical framework, centered around the concept of transformative learning, is Mezirow's transformative learning theory. This theory is learners-centered and includes ideas and perspectives about the learning process and reflection as discourse that are key to making sense of a students' development (Mezirow, 1985). Specifically, a key component of the TI model is the exploration of different types of task-oriented learning connected to instrumental, dialogic, and self-reflective learning. This finding, which resulted in the creation of a transformative instruction (TI) model, provides a total overview of how to teach learners mathematics, as well as how task-oriented teaching can interact with the transformative cognitive development of students through learning as meaning schemes and different kinds of reflection. The logical combinations of different types of learning (task-oriented learning), the conceptual meaning of learning and reflection processes, are an important part of students' straightforward and profound understanding, as well as their transformative understanding of teaching mathematical content. The primary significance of the TI model lies in transformative teaching and educational practices through task-oriented learning as depicted in Figure 1.

Concerning RQ2 about the aspects of a TI model that should be included in an appropriate algebra-specific didactic approach for transformative teaching and learning, such a model can provide conceptual meaning to different types of learning. In the case of instrumental task-oriented learning, learners inquire about how they can best grasp an algebraic concept; in the case of dialogic task-oriented learning they explore when and where this learning could optimally take place, and in the case of self-reflective learning, they question why they are acquiring algebra-specific content. It is crucial to note that, regardless of the case, the learning process involves three types of learning that lead to transformation. These three types of learning, which are called "meaning schemes", are also an important part of a TI model related to students learning of algebra-specific content, i.e., *the first learning* process (learning within meaning schemes) involves learners working with what they have already learned (know) by expanding, completing, and repeating mathematical concepts and operations. *The second learning* process (learning new meaning schemes) is based on students being able to verbalize the algebraic methods or concept outcomes being discussed with other students and teachers. *The third type of learning* (learning through meaning transformation) is based on students' analyzing their own knowledge development of algebra content. A crucial point in students' learning of algebra through these diverse processes is that challenges, problems, and misconceptions can only be identified through the redefinition of such challenges and misconceptions in arithmetic. Transformation and transformative learning of algebra occur through students' critical self-reflection with the support of teachers during the learning process ("meaning scheme") of both prior knowledge of arithmetic and new algebra knowledge. In terms of the transformative teaching of algebra and the TI model, teachers' reflections play a crucial role in students transformative learning of algebraic concepts. Specifically, teachers analyze their students' work, systematize this information, and use it for future planning of classes.

As regards mathematical activities and algebra content, the key point of the TI model (Figure 1) is that the necessary prerequisites for TI include teachers' self-reflection about teaching and students' learning, motivation for professional development, and readiness for self-development and teaching improvement, as well as a continuous commitment to teaching algebra through the application of their own previous mathematical (algebra) knowledge of teaching. This suggests that as a transformative measure in learning, the TI model is influenced by these prerequisites and the teacher's perspective on their students' learning of algebra.

5.1. TI Model, Algebra Content and Task-Oriented Learning

While staying focused on the development of teaching practice as transformative teaching, it is important for teachers to fully understand how they can help their students use their prior knowledge of mathematics and actual learning. The primary focus of the TI model is on students' learning and the creating of mathematical concepts, with achievement as the main goal. This process is individual, with students' prior experience and knowledge forming the basis of learning new mathematical concepts, as illustrated by the theoretical aspects of the TI model (Figure 1). In this analytical study, the focus is specifically on the construction of transformative mathematical instruction called the TI model (RQ1), and logical analytical reasoning about how the TI model's conceptual context can be used in an algebraic-specific context (RQ2). More specifically transformative teaching with a focus on students' learning of algebraic rules and rational equations concerning students' prior knowledge, as well as whole and rational numbers in the framework of a task-oriented learning approach. Examples 1 and 2 below illustrate transformative teaching, guiding students' learning as a transfer within "meaning schemes" from prior knowledge to the generalization of the concept of equations and rational equations, as well as algebraic rules.

5.2. Conceptualization of "Meaning Schemes"

Example 1

Prior knowledge of inverse operations (addition and subtraction) will activate content and process reflection within the framework of task-oriented teaching of learners' straightforward understanding of a new meaning scheme about negative numbers. A profound understanding of negative numbers can be useful for teaching the generalization of algebraic rules, as well as "two minuses/pluses make a plus and minus plus make a minus" (e.g., Karlsson & Kilborn, 2024b).

Example 2

The relationship between rational numbers, ratios, and rational equations has been described by various scholars (e.g., Karlsson & Kilborn, 2024a). Research about the relationship between algebraic concepts can be used in the context of developing students' conceptual knowledge of transformative mathematical instruction: the TI model. Prior knowledge of rational numbers as equivalence classes activates students' straightforward understanding of new concepts of ratio and proportion, and this kind of knowledge is a prerequisite for students' profound comprehension of algebraic concepts and the generalization of rational equations (Karlsson & Kilborn, 2024a).

Summary

Examples 1 and 2 illustrate how students can receive diverse types of conceptual knowledge through the organization of teaching using learning schemes and task-oriented teaching strategies, starting with instrumental learning. The same conceptual content is used to design dialogic and self-reflective learning through teaching, with a focus on progression in students' work with actual content via verbalization, reasoning and reflections. The TI model, task-oriented learning schemes and reflection aspects, (see Figure 1), should be included in an appropriate algebra-specific didactic approach, as specifically applied in task-oriented learning.

The benefits of the TI model are more understanding of enrich effective algebra teaching, where student' algebra learning, and knowledge development is crucial. The study describes new theoretical directions in mathematics education with the main contribution being systematic theoretical knowledge of transformative teaching and learning of algebraic concepts.

6. FUTURE RESEARCH DIRECTIONS

The theoretical model (TI model) introduced in this study provides opportunities to implement TP and TL theoretical concepts and apply them analytically in future empirical studies. As regards further empirical studies focused on teacher educators' practices related to students' task-oriented learning, the present authors recommend incorporating the theoretical findings from this study in the form of the transformative instruction model (TI model).

The TI model that resulted from this study is very comprehensive and requires further research about transformative teaching and learning mathematics that needs to be expanded both theoretically and empirically. Theoretically, this means constructing more concrete teaching tasks with a focus on mathematical concepts related to the conceptual meaning of learning types and meanings schemes, including reflection and implementation, as well as empirical studies about teachers' transformative professional development and students transformative learning of mathematics, concerning the TI model.

Further empirical studies are needed that focus on the effects of implementing the TI model in a classroom setting, as well as how the TI model influences students' algebra achievement in the long term. This could refine the model based on practical classroom experiences and examine the benefits of the model, as well as its practical implications and challenges.

7. DISCUSSION AND CONCLUSION

In this chapter, theoretical aspects of transformative pedagogy (TP) and transformative learning (TL) in a task-oriented teaching context were analyzed to gain a better understanding of what constitutes effective mathematics teaching, with a focus on optimizing students' learning experiences, with examples related to algebraic concepts. The systematic organization and logical track reflection on these theoretical points highlight the significant potential of the study, particularly in the development of a transformative instructional design. The study's analytical findings, such as the transformative mathematical instruction model (TI model) provide advanced research in mathematics education, which combines a psychological perspective about teaching with learning and algebra content. The relationship between the TI model and algebra-specific concepts illustrated by the analytical findings, and particularly by Examples 1 and 2 show how algebraic concepts can interact with students' development in algebra, with a thematic emphasis on instrumental, dialogic and self-reflective task-oriented learning. Researchers implement analytical findings as TI model related to teaching and learning algebra, see Examples 1 and 2. Its led to comprehensively understand the structure of conceptual significance of transformative students' learning and how theoretically, it can be applied in practical teaching. Thus, the results provide an analytical framework for future empirical studies.

The benefits of the TI model are that it illustrates effective mathematics teaching and learning and contributes more knowledge related to arguments 1–5 (see background) especially the interplay between teaching algebra content and students' learning using a transformative approach.

8. LIMITATIONS

The current research highlights the limited theoretical and in particularly empirical studies about the transformative teaching of mathematics—specific content that analyzes and illustrates the transfer of concrete learning content from prior knowledge to new knowledge and to applying knowledge, for example, related to algebra or another type of mathematical content. This confirms the positive benefits of the TI model and the results in the form of the implications for algebra in Examples 1 and 2.

Also, a limitation of this study is that while the theoretical foundation for the transformative instruction (TI) model and its application to mathematics teaching has been presented, further empirical research is required to fully validate and explore its effectiveness in diverse educational practical settings. The theoretical approaches to TP and TL, which led to the construction of the TI framework proposed in this study, stimulate discussions on the structural aspects of the task-oriented teaching of algebra, providing a conceptually grounded model for transformative teaching and learning mathematics. The study offers a conceptual framework and examples (Examples 1 and 2) of how the TI model can be applied, particularly in an algebraic context, although it does not provide extensive empirical data or case studies to confirm the validity of the model on teaching practices or student learning outcomes. In addition, the generalizability of the TI model to other areas of mathematics education or to different students' populations remains to be tested in future research.

9. IMPLEMENTATION

The implementation of the TI model as designed for teaching and learning took place autumn 2024 in the upper secondary schools of Huddinge municipality in Stockholm with a focus on different types of learning and the transition from students' arithmetic to algebraic knowledge.

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Chapter # 13

PSYCHOSOCIAL SKILLS, EMOTIONAL UNDERSTANDING AND RESILIENCE RELATED TO ATTACHMENT IN YOUNG PEOPLE

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ABSTRACT

Adolescence is a stage of development of psycho-social skills through training and education. The goal of our research is on the bases of scientific theory and empirical research assemble psychoeducational methodology for development of emotional regulation and resilience of students and adolescents. The sample consisted of 367 adolescents. The respondents completed questionnaires The Child and Youth Resilience Measure, modified version of Situational Test of Emotional Understanding and a questionnaire of trait emotional intelligence. To obtain the results, we used a battery of questionnaires, which consisted also of IPPA-R questionnaire designed to measure the quality of the attachment to the mother, father and peers. The results have shown that adolescents in middle adolescence have lower rates of emotional regulation and resilience. We found out that the quality of the attachment influences the effectiveness of emotional regulation of adolescents. Our results also show that adolescents usually form a secure attachment in their relationships. We also found out that they form the least quality with their fathers and the most quality relationship with their peers.

Keywords: psycho - social skills, emotional regulation, attachment, relationships, resilience.

1. INTRODUCTION

A new trend in the investigation of emotional intelligence is also one of the elements of emotional intelligence, namely emotional regulation.

Emotion regulation became the subject of research in the 1980s, initially being incorporated into research dealing with emotions and their development (Thompson, 1994; Cox, 1994; Gross, 1999). According to Gross (1999), we can define emotional regulation as a set of processes enabling individuals to modify the expression and experience of unpleasant and positive emotions. Emotion regulation affects whatever emotions we have when we have them, how emotions are experienced by individuals (Gross, 1999). Thompson (1994) divides emotional regulation based on its regulatory sources into two types: self-regulation and social regulation (parents, friends). The most frequently defined elements of emotional intelligence models written by authors and researchers in their models are empathy, interpersonal relationships, evaluation and expression of emotions, self-awareness, motivation and communication.

Resilience - psychological resistance is classified as a modern term. Resilience first appeared in the 1980s. to the 1990s (Šolcová, 2009). Křivohlavý (2009) and Šolcová (2009) point to the connection between resilience and social support based on E. Werner's research from 1954. Resilience represents a dynamic process, the ability to become visible later in life after overcoming a problem or an adverse life situation (Newman & Blackburn, 2002). The authors describe the ways in which a child manages a negative life situation as: coping

focused on emotions (Coleman & Hendry, 1999), coping focused on a problem (Folkman & Moskowitz, 2000). Masten and Obradović (2006) defines resilience as the ability to withstand an adverse life situation or gain resilience when overcoming a negative life situation (trauma, death) and continue to develop effectively. He characterizes psychological resilience as a person's ability to successfully adapt despite negative and dangerous conditions in 3 forms (Masten & Obradović, 2006): at-risk children achieve satisfactory development, children manage stressful situations, and children are able to recover from psychological trauma. Despite all these definitions, as stated by McLean and Breen (2009), there is no unified and recognized definition of resilience.

We can define communication competences as abilities that allow us to communicate in interpersonal relationships (Hall & Lindzey, 1997). Liptáková et al. (2011) defines communication competences as human abilities enabling communication based on acquired knowledge, skills, attitudes and values, which are related to compliance with norms, principles, rules and tools of verbal interaction. According to Hall and Lindzey (1997), the basis for communication skills are innate personality traits, intelligence and emotional intelligence, proven ways of communication that are culturally conditioned from the point of view of the environment in which a person developed and currently develops.

According to a transdisciplinary American commission composed of elite scientists and practitioners (C.C.R., 2023), the alarming increase in the number of children and adolescents at risk of risky behaviour, depression, violence, various forms of addictive behaviour, as well as disinterest in education and culture, is linked to fundamental deficiencies in the educational and, in particular, relational environment. Both psychology and current neuroscientific findings confirm that there is a typical, ontogenetic and innate tendency for humans to associate specifically with close and trusted people, to seek mutual unity and understanding with other people, and to search for meaning and significance in their existence. According to neuroscientists, these innate tendencies are exerted by the interaction of stimuli from the environment and from within the organism (Vancu et al., 2024).

The basis of the functioning of the nervous system is integration, i.e. the way in which, based on the interaction of these stimuli, the individual components of the nervous system organise themselves into a functional whole, which is crucial for psychological balance and the functioning of the individual in the environment and in social relationships (Siegel, 2012).

The self-organising capacity of the developing brain operates under the conditions of a special relationship with close people, and depending on its quality, either psychological resilience or vulnerability is established (Schore, 2003). According to affective neuroscience (Damasio, 1998), emotions are dynamic integrative processes that originate in the socially conditioned evaluative processes of the brain. Another important finding is that the propensity of adolescents to take risks and seek out new and exciting stimuli and experiences is linked to physiological changes in the brain, which continues to develop and significantly reshape itself (Vancu et al., 2024).

2. THEORETICAL BACKGROUND

2.1. The Adolescence Period

During adolescence, adolescents seek to detach themselves from their primary relational figures and achieve emotional and behavioural autonomy (Cassidy & Shaver, 2016). This autonomy is not understood in terms of complete separation from relational figures, but is directed towards the adolescent's individuation. During this period, relational attachment functions are transferred from parents to peers and later to romantic partners

(Koepke & Denissen, 2012). Although detachment from the family is characteristic of this period, the established relational attachment to the family persists (Říčan, 2013).

Emotional regulation plays an important role in the emotional experiences of adolescents (Opitz, Gross, & Urry, 2012). During these stages, individuals acquire a broad repertoire of emotion regulation strategies, including adaptive strategies such as problem solving and cognitive reappraisal. As development progresses through these stages, acquired strategies can be used more flexibly and adapted to situational demands (Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001; Gabrieli et al., 2014). During adolescence, the ability to adapt regulatory strategies to a specific situation increases (Zimmer-Gembeck & Skinner, 2011). However, it is important to note that this development may not be linear, and the situations faced by individuals during adolescence may vary in terms of the degree of emotion regulation required (Howells, 2018).

2.2. Emotion Regulation

Emotional regulation is a part of emotional competence, thanks to which we know how to react to experienced emotions, what their significance is in our environment and how to evaluate them in order to be able to express them (Poláčková Šolcová, 2018). Emotional regulation changes the dynamics of emotions rather than their quality (Gross, 2014). Knowing how to regulate one's emotions is considered a critical skill for optimal functioning as an individual. It enables individuals to respond appropriately in social interactions, which facilitates their ability to cope with new, changing situations and stimuli (Gross & Thompson, 2007).

The ability to regulate emotions in early childhood is considered an important skill that plays a significant role in both the social and psychological functioning of individuals (Compas et al., 2017). Studies have shown that children who were able to show and regulate their emotions appropriately in a given situation had fewer internalising and externalising problems. Internalising problems include anxiety, depression or other somatic disorders. Externalising problems include problems with attention, behaviour or hyperactivity (Lougheed & Hollenstein, 2012).

Through emotion regulation, we influence the intensity, duration, and experience of experienced emotions (Gross & Thompson, 2007), depending on current implicit or explicit goals. Explicit implies conscious, effortful and controlled regulation, whereas implicit is unconscious and effortless. The ability to use any form of emotion regulation appropriately can be considered a sign of mental health (Gross, 2014).

In a study by Gust, von Fintel and Petermann (2017), a repertoire of 31-emotion regulation was found to be positively associated with children's empathy and prosocial behaviour. In their study, Lougheed and Hollenstein (2012) found that a limited repertoire of emotion regulation strategies was associated with internalising problems.

2.3. Types of Relational Attachment

The parent-child relationship is one of the first relationships a child forms and has a significant impact on their social and emotional development (Brumariu, 2015). Children who form secure relational bonds with their parents or primary relationship figures have fewer internalising and externalising problems (Brumariu & Kerns, 2010), are more sociable and form higher quality friendships (Pallini et al., 2014).

Psychoanalysts and social learning theorists have suggested that the mother-child relationship is based on the child's pleasure in having their physiological needs met.

However, Bowlby disagreed with this view and sought to demonstrate that the desire to form a relationship with a primary caregiver has a biological basis (Bowlby, 2010).

Relational attachment theory is based on the child's biologically encoded need to attach to the primary caregiver, usually the mother, and later to other caregivers (Bowlby, 2010; Bretherton, 1992). Based on the findings, relational attachment, according to Bowlby (2010), is an emotional bond characterised by a strong need to seek and maintain closeness with one's relational person, especially in situations of stress or strain. According to relational attachment theory, internal working models are developed in response to the quality of repeated interactions between the primary caregiver and the child, which are related to the formation of relational attachment and influence the child's expectations and beliefs about self and others (Bowlby, 2010). Brisch (2011b) states that internal working models can be partly conscious and partly unconscious. Separate working models are created for each person in the relationship. These models make the behaviour of the relational person and the child in relational situations predictable.

Each person develops a type of relational attachment based on the experiences they have in forming a relational attachment to a primary relational person (Brenning et al., 2012). A study by Vuilleumier (2012) addressed this issue and suggested that, in most cases, relational attachment types manifest as individual differences in responses in a neural network that otherwise generally supports emotion, emotion regulation, and social cognition (Cassidy & Shaver, 2016).

The emergence of relational attachment and the development of children's trust in parental support and protection when needed (Bowlby, 1982) is considered one of the most important areas of child development (Dixon, 2015). Children with secure attachment perceive their primary caregiver as a safe base and refuge in times of need (Brumariu & Kerns, 2010). When separated from the primary caregiver, the child expresses dissatisfaction through crying, calling, and searching for the primary caregiver (Ainsworth, 1985).

The formation of a secure attachment depends on the parent's response to the child's cues. An insecure relational bond is characterised by a child who does not seek out his or her primary relational figure during separation, exploration of the environment, or when experiencing difficulties in the moment (Chambers, 2017). Children with this relational attachment are characterised by inappropriate stress and anxiety when separated from their mother or in a stressful situation, which they express by crying loudly (Brisch, 2011a). Anxious attachment also has an impact on emotion regulation at the cognitive-neural level. Attachment anxiety is negatively correlated with gray matter volumes in functional areas that have the capacity to regulate negative emotions (Troyer & Greitemeyer, 2018).

In their study, Cyr et al (2010) argue that the accumulation of socio-economic risks leads to the emergence of disorganised attachment by creating a frightening and desperate situation for the attachment figure who could otherwise provide adequate care.

The relational bond can be affected at any time by both favourable and unfavourable influences. It is a continuum that can be altered by emotional experiences (Brisch, 2011b). An increase in negative or positive experiences over time can lead to changes in the relational bond. The relational bond serves as a regulatory system, and how individuals experience emotions drives contact with relational individuals (Parrigon et al., 2015). Relational attachment and emotion regulation are inextricably linked. Children who have formed secure relational attachments have a greater ability to manage and regulate their emotions compared to children with insecure relational attachments (Fearon et al., 2010).

3. OBJECTIVES, DESIGN AND METHODS

3.1. Focus and Description of the Project

The goal of the thesis is to compile and apply in selected classes a psychoeducational integrative methodology based on scientific theory and empirical research to improve interpersonal communication competences, develop emotional intelligence and resilience of teenage students and adolescents. The partial goals of the work are to determine the level of resilience and emotional intelligence related to attachment in adolescents.

Emotional regulation, a key component of emotional intelligence, has emerged as a critical factor in adolescent development. This capacity interacts closely with psychological resilience and attachment patterns, forming a triad of skills essential for healthy psychosocial development. Our research examines how these three elements are interdependent and have a relationship. These three domains, adolescent development, emotional regulation, and attachment, form an interconnected system. During adolescence, attachment patterns influence the development of emotional regulation strategies, affecting psychological resilience. This theoretical framework guides our investigation of how these elements interact to influence adolescent psychological development.

3.2. Design and Methods

The first questionnaire is based on an international project that examines resilience led by M. Ungar (2005). The questionnaire consists of 36 items based on 4 areas: individuality, relationships – family, friends, school; society, culture. These items determine the perception of the uniqueness of the respondent's personality, the influence of the environment. Respondents circle their answers on the appropriate scale. This scale expresses identification with the given statement from complete disagreement (1) to complete agreement (5).

We used the situational test of emotional understanding (MacCann; Roberts, 2008) as the second questionnaire in the research. With this test, we find out to what extent adolescents understand basic emotions and emotional situations. The situational test of emotional understanding contains 42 situations. Situations offer five emotions as a result of a particular situation. Each situation has only one correct answer, which respondents mark at their own discretion.

The third research questionnaire is the Trait Emotional Intelligence Questionnaire (Petrides; Furnham, 2001). The questionnaire examines how adolescents perceive their abilities and skills in various emotional situations, which are included in 4 factors: well-being (mental well-being), self-control, emotionality and sociability. Respondents express identification with the given statement from complete disagreement (1) to complete agreement (7).

The aim of this paper was also to examine the impact of relational attachment on emotion regulation in adolescents. To this end, the Inventory of Parent and Peer Attachment (IPPA-R) was used.

The questionnaire is designed to elicit perceptions of the positive and negative emotional-cognitive dimensions of an adolescent's relationship with his or her parents and friends. In other words, it assesses the quality of relational attachment to parents and peers and whether these people provide psychological security and support (Armsden & Greenberg, 1987). The questionnaire consists of 3 subscales, including level of mutual understanding and trust (9 items), quality of communication (8 items), and level of anger and alienation (8 items). The items are formulated as simple statements about how parents and peers behave in situations that elicit an emotional response (Michalčáková et al., 2010).

Relational attachment scores are collected separately for mother, father and peers. Participants record their responses on a 5-point Likert scale.

We distributed the questionnaire to the respondents in printed form, adapted to the age of the surveyed persons. Administration of the survey took approximately 45 minutes.

We selected these instruments based on their demonstrated reliability in adolescent populations ($r = .024$, $p = .844$). The IPPA-R was chosen for its unique ability to measure attachment across three key relationships (mother, father, and peers), while the resilience measure captures individual and environmental factors. The 45-minute administration time was determined through pilot testing to maintain participant engagement while ensuring thorough responses.

The research sample consists of 367 respondents. The age of the respondents ranged from 15 to 18 years, the average age of the respondents was 16.01 years, $SD = 2.05$. 231 girls and 136 boys in research. The students came from average socio-economic backgrounds. Of the total sample, 98.36% of students were from complete families and 1.64% were from families with only one parent present.

We implemented educational activities in the period from September 2023 to December 2023. The implementation took place at the gymnasium in Bratislava - the capital city in Slovakia. The sample consisted of 78 students (46 girls, 32 boys) aged between 15 and 16 years. To increase the effectiveness of educational activities, we divided the students into several groups of 13 students each. We carried out the activities during 45-minute and 90-minute lessons.

4. THE MAIN RESULTS AND RESEARCH DIRECTIONS

Research has shown that, despite negative situations, adolescent boys are in greater mental well-being than adolescent girls. When investigating self-control in expressing emotions depending on gender, it was shown that male adolescents have higher self-control than female adolescents. Students in late adolescence are more psychologically resilient than those in middle adolescence. Research has shown that full-value relationships (family, friends, school) help adolescents to increase their psychological resilience. The result of the research points out that students in the period of late adolescence are subject to their own self-evaluation, on the basis of which negative emotions (fear, sadness, disgust, frustration) come to the fore. The reason for the appearance of negative emotions is also the cognitive evaluation of negative life situations (Stuchlíková, 2007).

Students in late adolescence in our research know how to evaluate negative emotions more adequately, which increases their emotional intelligence. The factor of psychological resistance, individuality, is correlated with the factors of emotional intelligence.

We justify the research result by the fact that the resilience factor individuality contains elements: self-control, ability to solve problems, empathy, social support (Ungar, 2006). These elements are part of the factors of emotional intelligence: emotional self-awareness, problem solving, empathy, interpersonal relationships (Bar-On, 1997).

In terms of relational attachment, the results show that the difference in the rate of use of cognitive reappraisal for adolescents with secure relational attachment compared to adolescents with insecure relational attachment is statistically significant $t = 2.644$, $p = 0.012$. The difference in the use of expressive suppression between the two groups is not statistically significant $t = 0.926$, $p = 0.360$, although it is clear from these results that expressive suppression is used more by adolescents with insecure attachment.

Gender differences in the use of these strategies are negligible. The results support the findings of relational attachment theory. The data suggest that adolescents with secure attachment are more likely to use cognitive reappraisal, an adaptive emotion regulation strategy. Conversely, they use expressive suppression less than those with insecure attachment. That is, an established secure attachment promotes the use of adaptive emotion regulation strategies.

Our findings on the impact of relational attachment on psychological resilience and emotion regulation are consistent with several research studies (Tang, 2024; Girmé et al., 2021). In addition, some longitudinal evidence supported, with researchers finding that attachment security in adolescence predicts the choice of strategies that regulating emotion in adulthood. Stable insecure infants use more hypo-regulation strategies (e.g., repression, detachment) and less balanced-regulation strategies (e.g., openness, collaboration) in the face of relationship crises in adulthood than stable secure infants; while unstable insecure infants employ more hyper-regulation strategies (e.g. exaggerated emotional expression, introspection) (Girmé et al., 2021).

The results show that girls have the most secure relationship with their peers, whereas boys have the most secure relationship with their mother. Insecure, specifically ambivalent, relational bonds are predominantly formed by girls with their mother and boys with their father. The implemented educational activities, which focused on the development of emotional intelligence, resilience and interpersonal communication competences, increased the skills of adolescents. A comparison of the entrance and exit test, which determined the level of subjective perception of emotional intelligence and resilience, showed changes in the level of perception of adolescents.

The results showed an increase in the level of all factors of emotional intelligence and resilience after the application of educational activities.

The most significant changes occurred in the factor of psychological resistance, individuality, relationships, and in the factor of emotional intelligence, emotionality. We justify the result by the fact that adolescents had the opportunity to think about themselves, their feelings, and values during the implementation of educational activities.

Individual research findings can be used to design practical programmes to promote young people's emotional and social competence and thereby strengthen their psychological resilience (Vancu et al., 2024). The target audience for practical prevention and intervention applications with young people would be educators, school and counselling psychologists, special educators and the school support team.

Future research and further exploration of cultural, socio-economic and gender influences on different types of relational attachment and their impact on resilience and emotional regulation would be useful. Different cultural contexts may lead to different forms of attachment and emotional coping mechanisms. It would also be interesting to explore in more depth the impact of young people's digital environments and virtual interactions on attachment and cognitive-emotional regulation and metacognition.

We are also aware of the limitations of the research, where the results of our findings in young people at a critical developmental stage may have been influenced to some extent by post-pandemic events in their mental health.

5. CONCLUSION

The results showed that adolescents in the period of middle adolescence have a lower level of emotional intelligence and resilience than adolescents in the period of late adolescence. Based on this finding, we created and applied a psychoeducational integrative methodology to a sample of adolescents.

By comparing the input and output test after the application, we achieved an increase in the level of emotional intelligence and psychological resilience. The biggest change occurred in the factor of individuality and emotionality. Our findings also showed how relational bonding relates to emotion regulation in adolescents, as we believe it is important to encourage the formation of peer relationships, which play an important role during this period. Our research showed that our participants had the best relational bonding with their peers. Several studies show that individuals with good relational bonding are better able to regulate their emotions and also use adaptive emotion regulation strategies (Brumariu, 2015), which was confirmed in our research.

We attribute the increase in these factors to appropriately chosen psychoeducational activities that enabled students to gain personal integrity, improve interpersonal relationships, and develop social skills necessary for life and cooperation. The created psychoeducational activities have proven their effectiveness and we recommend their implementation through the Personality and Social Development classes at high schools.

While our findings demonstrate the effectiveness of psychoeducational interventions in enhancing emotional intelligence and resilience, several limitations should be noted. The short intervention period (4 months) may not capture long-term effects. Future research should consider longitudinal designs tracking development over multiple years. Additionally, we recommend specific implementation strategies for schools, including (1) integration into existing curricula, (2) teacher training requirements, and (3) assessment protocols.

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Chapter # 14

TEACHERS' CHALLENGES NAVIGATING THE PROVISION OF SUPPORT TO LEARNERS WITH SPECIAL NEEDS: MAINSTREAM RURAL SCHOOL PERSPECTIVE

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ABSTRACT

Implementing support to learners with special needs in South African schools has largely been presented with challenges which increasingly make it difficult for teachers to navigate their provision of support. Thus, the pragmatic realities show that there is a need to identify and combat such challenges. This study investigated challenges experienced by teachers in their attempt to support learners with special needs. The study is underpinned by the social constructivism paradigm. The study used the transformative learning theory. The phenomenological qualitative research approach was employed to explore teachers' challenges in providing support to learners with special needs in mainstream rural schools. Data were collected using focus group interviews, with 36 purposively selected teachers in 6 schools. The collected data was thematically analysed and interpreted using Braun & Clarke methods. The study discovered the following as challenges hindering the provision of support to learners with special needs: lack of competency in managing the diverse learning needs of learners; limited resources; as well as a lack of training in attending to learners' learning needs. The study recommended resource allocation, teacher professional development training, and initiation of collaborative networks, to be in place for the alleviation of the support challenges experienced by teachers.

Keywords: challenges, mainstream schools, special needs, support, teachers.

1. INTRODUCTION AND BACKGROUND

The Salamanca Statement and Framework for Action on Special Needs Education, and the Education White Paper 6 (South Africa. Department of Education, 2015) view supporting learners' learning needs as a pivotal initiation which should promote equality in the educational setting. Both documents deem it mandatory for all learners to be supported academically regardless of their physical conditions, intellectual capacities, social standards, emotional positions, linguistic capabilities, or other conditions (UNESCO, 1994). Clear measures of support and intervention have been laid out by the Education White Paper 6 (South Africa. Department of Education, 2015), aimed at ensuring that all learners experiencing barriers to learning are educationally supported to the level of the demands of their experienced learning difficulties. Thus, the provision of support to learners with special needs is said to occur at different levels such as the initial screening guided by the learner profile; identification and assessment of barriers to learning; and supporting the identified learning needs, which is guided by the Support Needs Assessment

Form 1 and 2 (South Africa. Department of Education, 2014). The context of the SIAS Policy document considers the need for teachers to be proficient in their ability to possess a conceptual understanding and practical demands of providing support to learners with special needs. However, due to a lack of support in rural schools, teachers are therefore responsible for increasing their knowledge of support needs (Mawila, 2023).

The provision of support to learners with special needs in rural mainstream schools is challenged with frustrations and complaints from teachers, often because of the overpopulated classrooms, which makes it almost impossible to support all learners' learning needs (West & Meier, 2020; Tshangana, Nomtshongwana, & Buka, 2023). On the other hand, a shortage of equipment, teaching aids, and well-suited infrastructure often poses a significant hindrance to teachers in the rural mainstream schooling system (Modikoa Pillay & Shipalana, 2023). In addition, large class sizes have been identified as a hindrance to supporting inclusive education practices (Masana & Kgothule, 2022). Among other contributing factors, mismanagement of disruptive behaviour is often reported as a result of overcrowding (Gagnon, Sylvester, & Marsh, 2021).

Challenges around teachers include limited access to information and training in dealing with learners with special needs (Engelbrecht, 2020). Teachers tend to demonstrate a sense of learned helplessness, which in turn, reduces the conducive learning environment, further limiting levels of possible support towards learners with special education needs (Adewumi, Mosito, & Agosto, 2019). This tends to position learners as referred cases to special schools, or categorised as progressed, all due to their learning needs being unidentified and thereby unsupported (George, 2019). In some cases, they are left to repeat a grade, tempering learners' self-esteem, causing victimisation, and eventually dropping out of school. According to Traya and Lopez (2023), teachers tend to feel threatened by the demands and difficulties that lie with teaching in mainstream education settings, where they tend to doubt their ability to support learners' learning needs accordingly. Moreover, Nseibo, Vergunst, McKenzie, Kelly, Karisa, and Watermeyer (2022) demonstrated such to occur because of a lack of teacher support, training, and preparation.

In mainstream rural settings, learners come from unsupported homes, where parental involvement is absent (Muthukrishna & Engelbrecht, 2018). Furthermore, learners from low-income raking homes tend to perform poorly in their academic performance, as those raised by their grandparents severely lack academic progress due to the lack of support at home (Owens, 2018). Moreover, some parents in rural settings seldom engage in their children's educational affairs and leave it to the school to carry the entire burden (Stelmach, 2020). In addition, a lack of parental support makes it unbearable for teachers to function (Munje & Mncube, 2018). Despite inclusive education policies embracing values of equality and diversity (South Africa. Department of Education, 2015). Learners with special education needs and those from impoverished households tend to be viewed by teachers and other learners as different (Owens, 2018). Where teachers are unable to comprehend their attitudes as being discriminatory and contradictory towards the right to access education, which is negative (Muthukrishna & Engelbrecht, 2018).

1.1. Support Needs Challenges in Mainstream Rural Schools

The study focused on rural mainstream schools to develop the understanding of teachers' challenges with the provision of support to learners' learning needs. Support within these areas is proven to be difficult because of the remote location in which schools are based. Rural mainstream schools face unique challenges that negatively affect the quality of learners' learning. Teachers in rural mainstream schools work with limited resources making it increasingly difficult to deliver the curriculum effectively. This then

translates into teachers' inability to support the learning needs of learners with barriers to learning due to a lack of specialized equipment (UNESCO, 2022). Bringing to light the lack of professional development and training opportunities for teachers (Petersson-Bloom, Leifler, & Holmqvist, 2023). According to Du Plessis (2014), learning might be difficult within the rural school context as support even in the form of extracurricular activities would lack profusely. Both teachers and learners experience limited access to professional guidance and support due to scarcity of support services. They were ultimately leading teachers to function in isolation which is detrimental to their mental health (Dempsey & Mestry, 2023). Contextual challenges that rural mainstream schools are confronted with include a lack of adequate facilities and technological resources needed to foster quality learning and learner development (Chang & Kabilan, 2022). Moreover, factors influencing the provision of support to learners with special needs in rural mainstream schools have largely been identified to be policy implementation, lack of funding and lack of implementation capacity (Masana & Kgothule, 2022). Additionally, teachers' complaints tend to center around challenges relating to unsupportive school environments, declining learner well-being, and insufficient collaboration between parents and teachers (Cele, 2023). Nel, Tlale, Engelbrecht, and Nel (2016) together with Madiba and Materechera (2020) further highlighted that the prevailing negative perceptions of teachers exacerbate difficulties in addressing learners' needs effectively. More especially if the above-mentioned challenge prolongs over a long time.

It is important to take into consideration how schools in rural settings are confronted with high levels of unemployment and poverty. As a result, schools in rural settings are unable to accumulate sufficient funding and resources as schools in these contexts fall within the no-fee paying category (Berry & Gravelle, 2018). Thus, in this situation, schools would encounter financial constraints that force teachers to navigate the support by improvised methods, as resource shortage would be a major challenge. Moreover, because of these socioeconomic challenges, parents would often find themselves not affording to support their children by ensuring that they get proper diagnosis (Munje & Mncube, 2018). In such circumstances, learners' learning barriers remain undiagnosed, placing more pressure on teachers who ought to support them in the absence of a professional guide.

Secondly, it is equally important to realise how cultural perceptions and beliefs surrounding disabilities affect how learners with special needs are viewed in rural communities. There tend to be stigmas and held ideologies explaining how learners with related disabilities are looked at and understood. Such that, families or parents would be reluctant to seek professional assistance regarding the experienced barrier within their children (Hoppey, 2016). Explaining how these culturally held attitudes hinder inclusive educational practices as well as collaboration with parents to support learners experiencing learning barriers (Du Plessis, 2014).

2. THEORETICAL FRAMEWORK

The current study is premised on transformational learning theory by Jack Mezirow (1978). The theory focuses on changes that happen after learning (Hay, 2025). Transformative learning theory emphasizes the need for effective changes in individuals' frames of reference (Fleming, 2022). In this study the transformative learning theory is used to help teachers to navigate support services in rural schools. This may suggest that through the use of the theory teachers' perspectives will be transformed so they can navigate support services to learners who experience barriers to learning. Rodríguez and Barth (2020) argue that the transformative learning theory explores how people evolve their

understanding and worldview through critical reflection. This means that teachers are supposed to reflect on their challenges in supporting learners so they can improve their teaching practices. Uddin (2019) also argues that teachers are the agents of change as they aim to make inclusive education meaningful by using suitable teaching pedagogies. This suggest that teachers can improve on the support they render to learners with special needs if their needs are attended to.

3. METHODOLOGY

According to Creswell (2014), the qualitative research approach is an in-depth and subjective study that investigates people and events in their natural settings. This study used a qualitative research approach, to draw an understanding of teachers' personal experiences in supporting learners learning needs. The paradigm of this research is social constructivism, and through the use and application of this paradigm, subjective knowledge and understanding of teachers' experiences were investigated regarding support within mainstream schools of Mafikeng (Wahyuni, 2012). The study made use of phenomenological design to describe, interpret and make sense of the experiences of respondents about the phenomenon (Creswell, 2014). This research study made use of focus group interviews, face-to-face, open-ended and unstructured as a data collection strategy to obtain information that would answer the research questions (Qu & Dumay, 2011:245). Data were thematically analyzed using the six steps of Braun and Clark (2014). The study is approved under the ethical number (N W U - 0 0 1 9 0 - 19 - A 2). Braun and Clark's (2019) six steps were used to analyze the data.

4. DATA PRESENTATION AND DISCUSSION

The study has accumulated rich data from over 36 research participants in all 6 schools visited in the rural settings of Mafikeng, in the North West Province, South Africa. However, only a few responses are presented as a result of the restricted number of pages for the article. Focus group interview data shows a lack of teacher competency in catering to the diverse learning needs of learners; limited resources; as well as a lack of thorough teacher training in the development of skills and expertise, around the provision of support to learners with special needs. The results of the study are discussed under the following headings, namely, learner support needs; nature of support administered; and lack of training and resources. The novelty work of the findings below demonstrates how supporting teachers within mainstream rural school settings tends to receive less attention. Further highlighting the existing gap between inclusive education policy and policy implementation within rural school settings.

4.1. Learner Support Needs

Table 1.
Sampled responses on learner support needs.

Research Question: What learning needs do you encounter among learners in your Classroom?
Teacher 1, School A: "They can't read and if they can't read then they can't answer the questions in the examination."
Teacher 2, School B: "They can't cope in class, we have also noticed that they tend to have a low concentration span and are unable to pay attention for a longer time."
Teacher 4, School E: "There are few who have visual problems, and they can't see, in that regard, they tend to all want to sit at the front row. They often come from abusive families, in that way, if the learners already have barriers to learning it worsens the situation."
Teacher 4, School D: "Cognitive needs, for example processing new information and thinking Independently."
Teacher 3, School F: "Other learners do not have parental support, as means of assistance or internet provision to complete projects, and to some extent, it is because other learners are in situations of child-headed families, where now they assume the responsibilities of caring for the younger ones."

The displayed shows how teachers are confronted with the complexities of learning barriers which they lack the basic skills to support. Furthermore, it showed that they have not been exposed to any formal training, or preparation to be in the position of administering care and support to the learning needs of learners with special education needs. All of this alludes to the ineffectiveness of the District Based Support Team (DBST) in matters relating to support services rendered to schools. Teachers are concerned about the existing lack of the resources required to include, accommodate, and support the diverse learning needs of learners.

The posed findings resonate with that of (Engelbrecht, 2020) on issues pertaining to the helplessness there is in inclusive education practices due lack of pedagogical knowledge and teacher training thereof in dealing with learners with special needs.

Based on the above responses, factors related to the low socio-economic status of the learners and issues around them being in child-headed households contribute to teachers not knowing whether learners in question have barriers to learning, or if such barriers to learning are rather perpetuated by factors themselves. Furthermore, learners are reported to be lacking in their reading and writing abilities, where quite a substantial number have been observed to show signs of low concentration span. It is therefore reported that such learners tend to fall victim to bullying, "They are often ridiculed in class as a result of their barriers to learning or struggle", said teacher 5 of school D.

4.2. Nature of Support Administered

Table 2.
Sampled responses on the nature of support administered.

Research Question: In what ways do you include (administer care and support) learners with special needs in your classroom?
Teacher 3, School A: "Not having the skills to administer care and support to learners with special learning needs, I find myself helpless."
Teacher 2, School B: "I am not trained to perform the skills of a special needs education teacher and I am not have being trained for that."
Teacher 4, School E: "We report special needs cases to the Department of Education, but often it does not solve the problem."
Teacher 5, School C: "For those who cannot see properly during examinations we prepare A3 question papers for them to see."
Teacher 4, School D: "It is difficult to include them with limited resources, we often want to include them, but the absence of the resources becomes the problem."

Teachers attested to the fact that their support methods may have not been as successful and effective as anticipated. However, some maintained to have observed their methods yielding better results, while on the other hand, other teachers reported to have had no other methods to utilise. It was rather interesting to observe teachers' resilience despite their functioning in isolation, without prior training or preparation, and with limited resources. Even with the intervention strategies laid out, teachers admitted that their strategies may have not always been effective in successfully supporting the existing learning needs in their schools.

This reveals how teachers are confronted with extreme difficulties while attempting to support learners' learning needs. Where despite the guidelines and policies formulated, clear practical directions to affect such directives are not adequately relayed. Even when teachers are to assume the role of an interventionalist in their classrooms as asserted by Buli-Holmberg and Jeyaprabhan (2016). It remains that teachers are to be thoroughly trained and supported on how to actualise the already existing Support policy documents that should guide the process of support in their classrooms.

Rural schools struggle to access customised educational materials necessary to cater to the learning demands of learners' learning needs. Lack of such resources disadvantages the learning process, while burdening teachers with time-consuming activities e.g., creating the resources themselves (Donohue & Bornman, 2018). Such matters exacerbate teachers' challenges, making it increasingly difficult for them to navigate support to learners with special needs. It is however important to consider how constant teacher improvisation due to a lack of resources may likely lead to a decline in teacher morale (Madiba & Materechera, 2020). Eventually resulting in less individualised support for learners with specific learning needs (Berry & Gravelle, 2018). With that said, more sustainable solutions regarding the matter need to be attended to with practical and tangible intervention measures. Such as Government and policy support structures advocating for increased funding and provision of customised educational materials and infrastructure development in rural schools.

4.3. Lack of Training and Resources

Table 3.
Sampled responses on Lack of training and resources.

Research Question: What learning needs do you encounter among learners in your Classroom?
<i>Teacher 2, School B: "Teachers need comprehensive training about inclusive education."</i>
<i>Teacher 5, School C: "There is a need for thorough training sessions from the department of education, instead of just dumping us with the responsibilities and not teaching us on how to deal with it."</i>
<i>Teacher 4, School D: "I need to be taught how to care for and support learners' learning needs, especially those with learning disabilities. As a teacher, I am not capable of knowing one hundred per cent if learners have barriers to learning or not."</i>

Lack of training and the unavailability of resources posed a threat. The fact that 30 teacher participants reported to have not received training of any kind on how to support learners with special education needs. The above responses depict the strain and number of difficulties under which both teachers and learners are functioning. It further appears as though the participants lack a basic understanding of their duties relating to supporting learners' diverse learning needs, especially those with special needs.

The above results are in harmony with those of Hoppey (2016) as well as Nseibo et al. (2022), who discovered a prevalence of inadequate teacher preparation and training. Furthermore, the study conducted by Engelbrecht and Muthukrishna (2019) demonstrated how South African teachers within rural mainstream settings face significant challenges in the process of supporting learners with special needs. Both Engelbrecht and Muthukrishna (2019) and Engelbrecht, Nel, Nel, N, and Tlale (2015) encountered a lack of teacher training and lack of ongoing professional development of teachers have been one of the determinants leading to teacher challenges. Thus, according to Makoelle and Burmistrova (2020), professional development training programs would have to be tailored for mainstream schoolteachers within rural settings. With a clear focus on effective teaching strategies for special needs learners.

5. RECOMMENDATIONS

For learners with special needs to be adequately supported, measures would need to be taken to ensure that there are infrastructure improvements where individual learners' needs may be attended to. This is where sensory-friendly school environments would be created and make accessible special education material such as communication devices and boards, audiobooks, large print boards, pencil grips etc.

Teachers could focus on developing individualized and tailored educational plans which will inform their instructional methods in the process of teaching and learning (Walton & Engelbrecht, 2022). This way teachers can be prompted to differentiate their lessons to ensure that teaching and learning is being individualized to each learner's learning needs. The challenge around lack of training and resources may be resolved through the use of teacher professional development programs, such as workshops and ongoing training courses around pressing issues relating to support for learners with diverse educational learning needs (Petersson-Bloom, et al., 2023). Furthermore, School-Based Support Teams (SBSTs) may be given quarterly comprehensive training and equipped on the high demands and complexities of handling the educational needs of learners with special needs. Moreover, teachers would need to undergo practical training where related special education methodologies and pedagogies are initiated per school following the educational needs experienced.

Additionally, mentee-mentorship programs can be established where inexperienced teachers can source support from experienced teachers in special needs education. School management in collaboration with the school governing bodies could work on plans with actionable implementation plans on securing funding from educational NGO's, government departments and other donors. Further looking into fundraising opportunities within their communities (Cele, 2023). The essence of collaboration between different structures, systems and role-players in schools would need to be realized and strengthened for support to be affected.

Teachers may employ strategies that may assist them navigate their day-to-day challenges. Where for instance they may enhance and sharpen their knowledge of how to apply methods of support at their schools (Richards, 2016). This can be done through reading appropriate materials and engaging with related textbooks and literature on Special Education Needs. The impact can result in peer learning and training which when applied would foster collaboration among teachers.

6. FUTURE RESEARCH DIRECTIONS

The major insights presented in the study were shown to be teachers' lack of basic skills to support learners' learning skills to supporting learners' learning; poor supporting structures from the Department of Education; impractical policy guidelines and implementation especially within the context of rural mainstream schools; and lastly, lack of training and unavailability of resources. The gap or limitation leading to the need for future research is the impact of professional development and training programs in the rural mainstream school context. In the current research study, lack of teacher training has been overly emphasised, however, the explanation of such results is underexplained. Thus, future research will examine the impact of professional development and training programs on rural mainstream teachers' ability to support learners with special needs. The research would employ mixed research methods to make room for a broader and holistic understanding of the research problem. The combination of quantitative and qualitative methods would provide a comprehensive understanding of the impact. Quantitative methods could measure changes in teachers' knowledge, skills, and students' outcomes, while qualitative methods could capture teachers' experiences, perceptions, and challenges.

7. CONCLUSION

From the results of the study, it is evident that teachers in rural mainstream schools want to support learners with special needs. However, it is also evident that teachers are burdened and left to function in isolation. Making it greatly difficult to navigate their way in fully supporting learners' learning needs. A major concern is that teachers have not been adequately trained to navigate the demands that comes with supporting complex learning needs within inclusive education practices. The implications, therefore, show this to have considerably hindered teachers from meeting the inclusive education demands. The overall predicament ultimately places the learners in a disadvantaged position, due to lack of educational support. So long as responsible structures and stakeholders at the higher level of the education system do not engage collaboratively in resolving the existing challenges with practical and realistic solutions, teachers' frustrations will continue which will continue to have a negative effect on learners.

This research could therefore have a practical impact on bringing to light an understanding of the existing challenges that teachers are faced with in rural mainstream schools while supporting learners with special needs. Where in policy, the study's recommendation may bring about a practical guiding application on how support structures may assist teachers in navigating support amidst the challenges.

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Chapter # 15

TEACHERS' ATTITUDES IN MULTICULTURAL SCHOOLS IN ATHENS A Pilot Study

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ABSTRACT

Greece stands as the 'gateway to Europe', embracing waves of refugees and immigrants from diverse corners of the globe over the past three decades. Consequently, the educational landscape is undergoing a profound transformation, as students representing a kaleidoscope of backgrounds attend school in Greece. However, teachers are often left grappling with the challenge of adapting to this vibrant mosaic of diversity without support. This pilot study aimed to investigate the attitudes of twenty four teachers that attempt to navigate this multicultural milieu in three elementary schools in a highly concentrated multicultural area of downtown Athens. A survey was employed to assess how teachers' awareness of the challenges that multicultural and multilingual students face influence their ability to use adept teaching strategies. The results indicate that the more teachers are aware of these challenges, the more teaching strategies they employ. The findings also show that they feel unsupported in their efforts to bridge the cultural chasms between themselves and their students of varied backgrounds. Based on these findings this pilot study explores how teachers could be effectively supported by means of teacher training seminars targeting key areas of multicultural education.

Keywords: multicultural teaching, multilingual students, cultural diversity, teacher training.

1. INTRODUCTION

Globalization trends are creating an increasingly multicultural world; therefore, multicultural education should be a crucial concern in order to ensure students' social integration and inclusion. Greece has been on the forefront of accepting immigrants, due to the refugee crisis and the location and position in which Greece sits in the Mediterranean Sea. Greece is known to be a receiving country for refugees, as it is the first country into Europe that most refugees arrive at and claim asylum (European Website on Integration, 2015). According to the available evidence about half of immigrants and refugees in Greece reside in Athens, the capital, and make up about 17% of the population (Baldwin-Edwards, 2005) with a tendency for the numbers to keep increasing. Between 1991-2001 an estimated 630, 000 immigrants moved permanently to Greece (ReferNet Greece, 2022). In 2019, Greece hosted over 186, 000 refugees and asylum-seekers including over 5, 000 unaccompanied children (UNHCR, 2020). Children of these refugees and immigrants have been entering the school system over the past twenty years, especially in downtown Athens. Yet, the public school system has remained relatively unchanged, and the teachers do not seem to have much awareness of the importance of integrating multicultural and multilingual values into education (Zotou, 2017).

Given the high numbers of diverse students, it is imperative that the Greek school system find ways to integrate these students effectively. Despite the diversity seen in the population of Athens little has been done to address the training of teachers to accommodate such diverse classrooms. Teachers need to develop strategies for working with multilingual and multicultural students and their parents in a way that provides dignity and fosters a multicultural environment that will eventually promote inclusion and integration of these students. More research is necessary to investigate how teachers deal with diversity in the classroom, what their attitudes towards multicultural education are and what kind of support and professional development opportunities they need so that they can cater to their students' needs effectively.

2. BACKGROUND

Greece first began to develop a legal framework for intercultural education in the 1960s. Intercultural education aims to create an environment where power is not held by one group, but instead students of all cultures can thrive together in school. In 1960, a Greek policy first stated intent for the inclusion of foreign students. This policy, however, was fully based on the assimilation model, which forces children to adopt all lingual and cultural aspects of the host culture, and to abandon their previous language or cultural practices. This approach is not acceptable today and encroaches on the rights of individuals and families. Although in 1996 a law was introduced declaring equal opportunities for Greek and foreign students, this law did not address the various cultural backgrounds students come from, and the barriers that students face in accessing these 'equal opportunities' (Giavrimis & Dimitriadou, 2023; Zotou, 2017). Although the laws at this point expressed the desire for inclusion of cultural and linguistic differences, the education system is still based on a monocultural approach that does not give any time or value to other cultures or languages (Giavrimis & Dimitriadou, 2023).

In the Greek classrooms there is a highly diverse student population, in terms of ethnicity, language and culture. Yet, the educational system that teachers serve does not seem to be multilingual and multicultural enough. Even the terms are used interchangeably, despite not being synonymous. In this context, 'multilingual' refers to students who are learning the language, while 'multicultural' is a broader term that can be used to describe the way of life of second-generation diverse students who may already speak the language (Lid, 2018). Several studies regarding teachers and diverse classrooms in Greece focus on the lingual aspect of diversity and on refugee populations (e.g., Fotiadou, Prentza, Maligkoudi, Michalopoulou, & Mattheoudakis, 2022; Giavrimis & Dimitriadou, 2023; Gkaintartzi & Tsokalidou, 2011; Karananou, Rousoulioti, & Kontoulis, 2022; Zotou, 2017). Even though lingual diversity and refugee populations are key areas of research, they do not often emphasize the importance of breaking down cultural barriers and including cultural differences into the curriculum to approach education from a truly multicultural lens. Teachers in multicultural classrooms should integrate lingual and cultural aspects into the classroom (Yoon, 2023) to engage multilingual students and students who may have different values and expectations due to culture. The focus on refugees usually does not include non-refugee immigrants and children who are second generation immigrants and come from families who are culturally ethnic. Teachers must build awareness of the difficulties these students have in the school system due to the contrast between home and school culture. Different cultural cues and values such as concepts of honor and shame, can create a divide in the communication between school and home.

Most studies show that the majority of teachers in Greece express positivity towards teaching diverse populations of students (Fotiadou, et al., 2022; Giavrimis & Dimitriadou, 2023; Gkaintartzi & Tsokolidou, 2011; Karanikola, Katsiouli, & Palaiologlou, 2022; Zotou, 2017), but this is not the case practically in the classroom, possibly due to the lack of training and professional development. Fotiadou et al. (2022) showed by means of self-report questionnaires that most teachers in Northern Greece claim to support bilingualism but are left to their own devices to adjust the curriculum. In the same study teachers reported that they were unaware of the capabilities of students in their first language, indicating that they have never heard their students speak their first language, not even on the playground (Fotiadou et al., 2022). There is also a small percentage of teachers that are negative towards bilingualism and would prefer that students never speak their first language; hence they convince parents to speak only Greek at home (Fotiadou et al., 2022; Giavrimis & Dimitriadou, 2023). In fact, Karananou et al. (2022) argue that teachers have high awareness of multilingual difficulties but feel challenged when it comes to strategies that foster multicultural environment. Thus, they resort to a form of assimilation, where the goal is to replace the home language of the students with Greek. This assimilation, though, prevents the great advantage that multicultural education can have towards developing the worldview of students (Karananou et al., 2022). In addition, research has shown that any literacy increases overall literacy, including literacy in a different language (Naqvi, McKeough, Thorne, & Pfitscher, 2013). Students who learn to read and have a strong vocabulary in a different language are likely to develop better reading skills and vocabulary in the target language, as well (Naqvi et al., 2013).

Despite claiming to be intercultural in policy, the Greek school curriculum cannot be labeled as intercultural in practice, as many schools are not inclined to create an intercultural education atmosphere in the school. Many teachers express positivity towards the inclusion of intercultural curriculum, but some declare that students should follow the cultural norms of the majority Greek culture, which indicates that adequate training for staff is needed to work with multilingual and multicultural students (Zotou, 2017). Even teachers hired to work in zones of educational priority (ZEP) have reported that they do not feel adequately trained to teach in a multicultural way, despite being hired to work in a school of only refugee and immigrant students (Karanikola et al., 2022). A recent study showed that adolescent immigrant youth are not often able to maintain both an equal Greek identity and an ethnic identity due to the assimilative nature of Greek society (Mastrotheodoros, Kornienko, Umaña-Taylor, & Motti-Stefanidi, 2021). This study found that not only is this dual identity vital for the personal well-being of the second-generation individual, but it would also hold many benefits for the majority Greek culture to have individuals with dual cultural identities. Overall, there seems to be discrepancy between policies, attitudes and teachers' abilities to foster intercultural education and promote diverse students' growth towards a truly multicultural school.

2.1. Multicultural Classrooms in Countries Other than Greece

Looking at how countries other than Greece have attempted to implement a truly multicultural school underlines the critical role of teachers in these efforts. For instance, the Finnish educational system is often featured as a model of innovative and holistic teaching approach. A study in a diverse area of Finland found that most of the teachers were monocultural and around half the teachers showed low levels of awareness of diversity, which inhibited their abilities to teach diverse students (Acquah, Tandon, & Lempinen, 2016). This may explain why ethnic minority students in diverse schools have difficulties obtaining academic success. The authors argued that cultural competence, defined as awareness of

multicultural issues, is a crucial factor for teaching multicultural classrooms successfully; thus, emphasizing the importance of seminars and other resources to provide support and diversity training to teachers (Acquah et al., 2016).

Competence in teaching multilingual students is connected to awareness of the issues these students face. Another study in Finland reported that teachers who were more aware about the challenges of learning a second language and the benefits of maintaining the home language, were more likely to encourage the use of the home language (Alisaari, Heikkola, Commins, & Acquah, 2019). In accordance with findings by Greek researchers (i.e., Fotiadou et al. 2022; Giavrimis & Dimitriadou, 2023), they also found that although teachers expressed positive mindsets towards multilingualism, they did not understand it as an asset in the classroom and many of them encouraged families to also use Finnish at home (Alisaari et al., 2019), in favor of a monocultural approach to education. The discrepancy in these studies between the positive mindsets towards multilingualism and practice in the classroom may be due to the research methods that were employed; that is, self-report measures may sometimes include bias and can be inaccurate. Teachers may have much lower awareness on diversity issues than they declare (Thomassen & Munthe, 2021).

Although most teachers report having a positive outlook towards multicultural and multilingual students, they have difficulties implementing Culturally Responsive Teaching (CRT) in class. This may be due to a variety of reasons. A large-scale correlation study in Belgium reported a connection between the ethnic background of the teacher and multicultural education (Agirdag, Merry, & Van Houtte, 2016). Specifically, they found that multicultural materials and concepts were more likely to be introduced in the classroom from teachers of different ethnic backgrounds. A case study that included videotaped classroom lessons on four different German teachers working in a remarkably diverse school, found that teachers' beliefs about diverse cultures and race impacted the level of CRT (Civittillo, Juang, Badra, & Schachner, 2019). This study also notes that implementing CRT can be a learned skill, and not connected to the ethnic background of the teacher. Professional development for multicultural education (PDME) was found to be correlated to teacher's self-efficacy in multicultural classrooms (TSMC; Choi & Lee, 2020). Not only did PDME affect TSMC, but the self-efficacy of teachers affected the perceptions teachers had of the school climate, making it a more positive experience for everyone (Choi & Lee, 2020).

The value of professional development on CRT is recognized by teachers across the globe and should be an essential component of teacher training in Greece and beyond. A key aspect of CRT is fostering engagement with families, particularly multilingual families. To effectively support these communities, professional development must equip teachers with the skills necessary for meaningful interactions with families. The ultimate goal should be to empower families to take leadership roles in meetings and events. However, research indicates that reaching this level of engagement requires extensive and sustained professional development (Schultz, Bonney, Dorner, & Song, 2023). Teachers play a crucial role in multicultural education, as their awareness and instructional strategies significantly shape a multicultural learning environment. When implemented effectively, CRT not only enhances classroom dynamics but also benefits students in measurable ways. Studies show that CRT training increases students' enthusiasm for learning (Azis, Maharani, & Indralin, 2024), improves test scores, and helps close the academic achievement gap between ethnic majority and minority students (Thomas & Sebastian, 2023). Additionally, CRT fosters a stronger sense of identity and more positive attitudes toward students' ethnic and racial backgrounds (Byrd, 2016), reinforcing its role as a powerful tool for creating inclusive and equitable learning spaces.

3. THE PRESENT STUDY

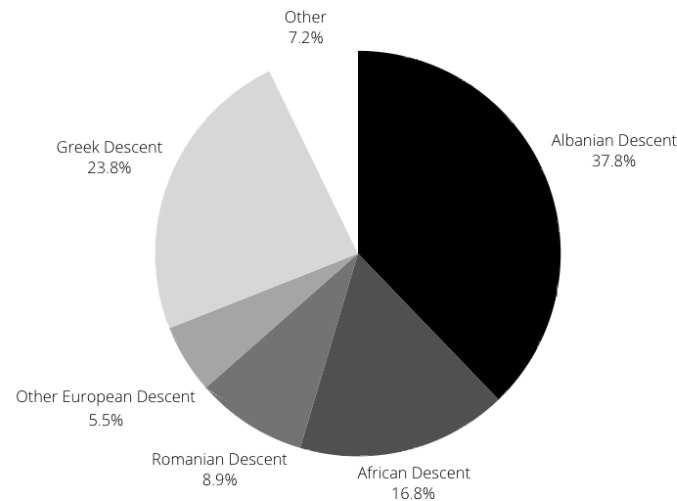
The present pilot study aimed to investigate teachers' awareness about multilingual and multicultural challenges of the students and to examine the connection between this awareness and the strategies that they employ to support these students, as highlighted by previous research (Acquah et al., 2016). Despite efforts to identify the barriers to multicultural education in Greece, there is a pressing need for further research with teachers working in schools with highly diverse student populations, such as in Athens. Most previous studies on teachers' experiences with diversity have been conducted in Northern Greece or the islands, often focusing on the challenges faced by refugee students. In contrast, this study focuses on a highly diverse neighborhood in central Athens, where the largest percentage of ethnic minorities in Greece reside. The hypothesis of this study is that the more aware teachers are of the challenges faced by multilingual and multicultural students, the more likely they are to develop and implement effective strategies to meet these students' needs. However, given the reported lack of teacher training in Greece, this study also seeks to explore how teachers can be better supported through professional development, not only to increase their multicultural and multilingual awareness, but also to help them acquire the practical skills needed to apply this knowledge in the classroom.

4. METHOD

4.1. Participants

This study included 24 teachers (4 male and 20 female), all of whom currently work in one of three public elementary schools in downtown Athens that participated in this research. All participants hold a teaching degree and teach grades 1- 6. The age range of the teachers was between 31-64 years ($M = 46$, $SD = 10.29$) and a range of 5-37 years ($M = 20.52$, $SD = 10.60$) of teaching experience. The specific schools were selected because they are in Kypseli, which is a neighborhood of Athens with a high concentration of immigrants (Karananou et al., 2022). For many years, the schools in this neighborhood have had a high concentration of diverse students. This was confirmed in the survey's demographic results (see Appendix II), as teachers reported a high ethnic diversity of students in their classrooms. Indicatively, an average of 23.8% of students in participants' classrooms were fully Greek; while over 75% of the students in these classes had at least one parent of another nationality (see Figure 1).

Figure 1.
Ethnic distribution of students in participants' classes.



4.2. Materials

This study adapted a questionnaire that was developed by Acquah et al. (2016) for a school in a multicultural neighborhood in Finland. It encompasses two parts: the first addresses teachers' level of awareness regarding lingual and cultural teaching, and the second addresses the strategies teachers use in the classroom (see Appendix I). There are 14 questions in the Awareness Questionnaire, seven of which are close ended questions on a six-point Likert scale with the following scores: 1 = extremely low, 2 = low, 3 = moderately low, 4 = moderately high, 5 = high, 6 = extremely high. One example of a close ended question in this selection is "Please indicate your level of understanding as to how culture influences learning." Seven additional questions are open ended, such as: "How many students from backgrounds different from your own did you have in your high school class while growing up?". The Awareness Questionnaire aimed to discover the teachers' personal experience with diversity and whether this made a difference in their awareness of diversity issues in their classrooms.

The second part of the survey, "Strategies for Teaching", has eight close-ended questions, also recorded on the same six-point Likert scale as mentioned above, as well as three open ended questions. An example of a close ended question in this section is: "Please indicate the frequency with which you use strategies for teaching academic content to multilingual learners?". The open-ended questions are included with the purpose of discovering in which areas teachers self-report needed support, such as "What three areas of professional development you would like to engage in to better support your work with multilingual learners?". The purpose of the second questionnaire was to understand in what areas of professional development teachers have concerns and need support to teach multicultural classrooms.

4.3. Procedure

The researcher visited the three public primary schools upon institutional review board approval for ethics and with permission granted by the school principals. The questionnaire

was distributed in a printed format. To ensure anonymity separate envelopes were provided, an envelope for consent forms, another one with the questionnaire and another one with debriefing forms. They were left on a table in the staff room so that volunteers could complete them at their convenience. The consent forms were all placed in one envelope when finished, and each questionnaire was returned in an individual sealed envelope to ensure anonymity within the school. The researcher returned to the school in due time and collected the envelopes.

5. RESULTS

5.1. Quantitative analysis

Spearman's rank correlation was computed to assess the relationship between the level of awareness teachers reported about diversity issues, and the total knowledge and skills in teaching strategies. There was a statistically significant positive relationship between the two variables, $r(23) = .49$, $p = .015$.

Regarding the scores, the participants showed the highest awareness score for "How language influences learning" ($M = 4.92$, $SD = .88$) as well as "How culture influences learning" ($M = 4.63$, $SD = 1.21$). The lowest awareness score was for "Language variation and dialects" ($M = 3.96$, $SD = 1.04$).

Regarding strategies used in teaching multilingual students, participants reported the highest score in knowledge and skills in "Strategies for teaching academic content to multilingual learners" ($M = 4.00$, $SD = 1.22$). The lowest score was in "Strategies for using students' native language and culture to enhance acquisition of academic Greek and grade level content" ($M = 3.46$, $SD = 1.44$) (see Table 1).

Table 1.
Highest and Lowest Scores of Awareness & Strategies Quantitative Questionnaires.

AWARENESS QUESTIONNAIRE	MEAN (SD)
HOW LANGUAGE INFLUENCES LEARNING (HIGHEST SCORE)	4.92 (.88)
LANGUAGE VARIATION AND DIALECTS (LOWEST SCORE)	3.96 (1.0)
GROUP MEAN	4.45 (.62)
STRATEGIES FOR TEACHING QUESTIONNAIRE	MEAN (SD)
STRATEGIES FOR TEACHING ACADEMIC CONTENT TO MULTILINGUAL LEARNERS (HIGHEST SCORE)	4.00 (1.2)
STRATEGIES FOR USING STUDENTS' NATIVE LANGUAGE AND CULTURE TO ENHANCE ACQUISITION OF ACADEMIC GREEK AND GRADE LEVEL CONTENT (LOWEST SCORE)	3.46 (1.4)
GROUP MEAN	3.72 (1.1)

5.2. Qualitative Analysis

The open-ended questions of the questionnaires were analyzed qualitatively based on the key themes that emerged from the participants' responses (see Table 2). Indicatively, the participants mentioned that incorporating the native language and cultural background of students in the lesson, offering emotional support and communicating with parents are the most important things to do to support multilingual learners. Whereas their principal areas of concern are barriers in the communication with the parents, lack of resources - including time -, and teaching Greek as a foreign language. They stated that they would like professional development in the form of seminars and resources in the areas of teaching Greek as a foreign language but also multicultural education and instructions on how to incorporate these aspects into their lesson plans.

Regarding participants' experiences with diversity, 30% (8/ 24) had a student from another ethnicity in their elementary school. 50% (12/ 24) had at least one student in their middle school from a different ethnicity, and 50% (12/ 24) had at least one student of a different ethnicity in their high school. Only 12.5% (3 / 24) had a teacher of a different background in school. Regarding racism, all participants reported feeling comfortable to discuss the topic with others. As for witnessing racism, however, 30% (8/ 24) claimed to have never witnessed racism. Of the 70% (16/ 24) who reported having witnessed racism, 21% (5/ 24) explained that they witnessed it on the bus.

Table 2.
Main Themes in the Qualitative Responses for the Strategies for Teaching Questionnaire.

The Most Important Things Teachers Can Do:	1) incorporate the native language of students into lessons	(37.5%) N = 9
	2) communicate with parents	(25%) N = 6
	3) emotional support for multilingual students	(20.8%) N = 5
	4) incorporate the background culture of students into lessons	(16.7%) N = 4
Barriers Teachers Face:	1) barriers with the parents of the students	(37.5%) N = 9
	2) the lack of resources from the government for multilingual students	(29.2%) N = 7
	3) the lack of time teachers have to properly teach multilingual students	(25%) N = 6
	4) teaching Greek as a foreign language	(20.8%) N = 5
Types of Professional Development Teachers Request:	1) seminars	(37.5%) N = 9
	2) resources from the government	(25%) N = 6
	3) learning how to teach Greek	(20.8%) N = 5
	4) education on different cultures	(20.8%) N = 5

6. FUTURE RESEARCH DIRECTIONS

Future research should focus on expanding the sample size of teacher participants to allow for a reliable and generalizable set of findings. This could be done also by recruiting participants from other multicultural areas of Athens. Perhaps interviews with teachers would allow more elaboration on awareness issues and examples of strategies that teachers employ in class. It would also be interesting to compare the findings from the areas with a high concentration of diverse population to findings with teachers who work at schools with exceptionally low percentages of multilingual and multicultural students.

The current as well as most of previous research with teachers in Greece is to a great extent based on self-report measures. However, self-report measures could potentially include implicit biases and lead to overestimation of positive attitudes (Karananou et al., 2022; Thomassen & Munthe, 2021). Consequently, there should be efforts to explore ways to directly record the level of awareness and strategies used in order to reduce potential biases. A possibility to build off current research would be to film teachers during lessons and quantify the results to record the strategies used in the classroom (Civitillo et al., 2019). Alternatively, following the survey there could be an intervention with teachers in the form of professional development seminars based on teachers' expressed need for practical training in multicultural issues. It would also be useful to evaluate the effect of this training on awareness and strategies after implementing suggestions from the seminars. Finally, future research should evaluate the impact of teachers' multicultural and multilingual training on students. It would be valuable to include students' perspective and specifically how they benefit from teachers who are culturally sensitive and effectively apply the principles of multilingual and multicultural education.

7. DISCUSSION

In this pilot study there was effort to investigate the attitudes of teachers who work in multicultural and multilingual schools at the center of Athens, where there is the highest concentration of immigrants and refugees. Through quantitative and qualitative measures, we investigated awareness of the challenges faced by multilingual and multicultural students and of strategies that should be used to support them. Highest understanding was reported for the effect of language on learning, followed by the effect of culture on learning, indicating that teachers have a moderately high understanding of how these two factors affect the learning process at school. Participants reported having the highest level of knowledge and skill in strategies for teaching academic content to diverse students, which illustrates that they feel they possess adequate strategies to teach the academic material to multilingual and multicultural students. In addition, the findings show a positive correlation between the level of awareness to diversity issues affecting learning, as reported by the teachers, and the strategies for teaching vastly multicultural classrooms. That is, the more awareness participants reported of the language and cultural barriers students face, the more strategies and skills they reported having for teaching multilingual and multicultural students in the classroom.

Overall, participants reported an elevated level of awareness, but this should be interpreted cautiously, as this was a self-report study. Although it is possible that teachers are well educated on multicultural issues due to the news, various media outlets, and experience, it seems unlikely that the awareness of teachers is as high as they report, since, according to their reported experience with diversity, about half of them were raised in areas with little to

no cultural diversity. Previous research also showed that although teachers may express positivity towards multilingual and multicultural classrooms, their responses to questions regarding their beliefs and strategies in the classroom show the opposite; thus, they did not implicitly believe in the advantage of a multilingual classroom (Karananou et al., 2022). This is consistent with findings indicating that self-reported scores may be overly high, hence overestimating positive attitudes (Karananou et al., 2022; Thomassen & Munthe, 2021).

The qualitative analysis of the open-ended questions indicates some interesting direction to determine teachers' needs for training and support. The issue of language was central to the teacher's perceptions. Interactions with the parents of students were reported as a main area of concern, mainly due to the language barrier. Yet, teachers reported that interactions with parents are one of the most important things they can do to support multilingual students. Teaching Greek as a second language was an issue of concern, whereas the inclusion of the student's original language into the classroom was mentioned as one of the most important things a teacher can do, consistently with the high levels of awareness expressed in the quantitative part in this matter. Another key issue in teachers' responses was the need for resources, training, and further professional development. Specifically, they expressed a need for resources and seminars about teaching Greek as a foreign language and education on cultural issues.

The importance of professional development programs for teachers has been highlighted by previous research (Giavrimis & Dimitriadou, 2023; Zotou, 2017). In fact, it has been found to be vital not only for increasing the self-efficacy of teachers in multicultural classrooms but also for improving their perception of the overall environment in schools, which affects students in every facet: behavioral, social, and emotional (Choi & Lee, 2020). Although there is a legal framework in Greece regarding multi-cultural education, education programs for teachers have not been successful in this area, and teachers are still seeking professional development opportunities in the area of multicultural education as seen in this as well as in previous studies (Dimitrakopoulos, 2004; Giavrimis & Dimitriadou, 2023; Parthenis, 2010; Zotou, 2017).

Based on the current findings, there could be suggestions for teachers' professional development in multicultural education and diversity coping, considering recent developments in this area. Specifically, the development of Culturally and Linguistically Responsive Teaching (CLRT) has been used for a focused training that helps teachers gain skills to engage multicultural and multilingual learners in the classroom (Yoon, 2023). CLRT focuses on five areas: 1) Knowledge of learner's first language, 2) allowing student to use both languages for learning, 3) integrating language learning with classroom content, 4) using multimodality, and 5) drawing on collaboration. Consequently, CLRT provides practical strategies towards understanding multicultural individuals and the barriers they face. Offering development seminars as an intervention to teachers who struggle with multicultural and multilingual classes may help them develop cultural sensitivity as well as appropriate teaching practices. Intervention studies have shown that teacher training seminars in applying culturally responsive teaching (CRT) resulted in the promotion of participants' self-reflection on their own cultural biases as well as the cultural standpoints of their students. They increased knowledge about CRT practices and confidence in implementing these practices in diverse classes (Pevac-Zimmer, Juang, & Schachner, 2024). Regarding the content of such seminars, explicit education into the historic, economic, and educational inequalities of the cultural groups teachers work with as well as assignments on diverse school cultures help increase teachers' cultural responsiveness and relevant strategies (Tanase & Kayaalp, 2024).

A key issue raised in the present findings is the language barrier that interferes with communication in the class and prevents engagement with the students and their families.

A practical skill to have in a multicultural classroom is based on CLRT and refers to language knowledge. Previous studies in Greece showed that some teachers encourage families to avoid speaking their language at home (Fotiadou et al., 2022; Giavrimis & Dimitriadou, 2023); however, these practices are inconsistent with multicultural education. Effort should be made to practically show appreciation of students' native language. Some knowledge of the sentence structure of students' native language could help the teacher both understand students' mistakes and how to effectively explain concepts (Yoon, 2023). Basic knowledge of a few words in students' language may help the teacher connect and build trust with the students and the students' families. In addition, the use of students' first language interchangeably with the target language (translanguaging) can be an appropriate student-centered pedagogical approach to teach diverse classrooms (Cenoz & Gorter, 2022). In this respect, translanguaging can be employed to enhance communication in class and facilitate content learning.

It is also important for language and curriculum objectives to intertwine to increase the effectiveness of the lesson (Yoon, 2023). Teachers should be trained to present several opportunities for students to learn aspects of the target language, such as vocabulary, which can be presented in context across different subjects taught at the school. The Organization for Economic Co-operation and Development (OECD, 2018) has presented ways students can build global competence throughout their fields of learning. These strategies can be tailored to match cultures present within a class or the school at large. Each subject of learning – for example, Literature, Science, Physical Education – can incorporate aspects of diverse cultures, which can help expand the worldview of students (OECD, 2018).

A relevant key issue that arose in this study was teachers' engagement with families, which was viewed as a major concern. However, engaging families in classroom activities is an important aspect of building trust and enhancing classroom life (Tye, 2023), as was also acknowledged by the participants of this study, as one of the most important things to do. Family engagement in school is vital to ensure that students stay in school and experience an increasing sense of belonging within the student body (Tye, 2023). Research has shown that extensive professional development is highly important for teachers to understand their role in this process and to have more successful interactions with multilingual parents (Schultz et al., 2023). Consequently, the teachers should be educated to view themselves as participants, rather than hosts, allowing parents more initiative and a significant role in creating a truly multicultural environment. Parents could increase ownership by taking opportunities to share with the class about their cultures and language and choose photographs or materials for classroom decoration that represent their culture (Banks, 1993; Baker, 2015). When teachers take time to understand the style and forms of communication of their students' parents, this enables them to not only understand the students better, but also to use similar expressions in the teaching environment to facilitate communication (Siliunas, Wan, & Edejer, 2024). Professional development seminars that address ways to engage families in classroom activities would be critical to enable efficient teacher-parent interactions to the benefit of the students.

Another critical issue to address is the relationship between teacher and students and students amongst themselves, and the creation of a safe, inviting space, which is key for a multilingual and multicultural education. It is important for teachers to aim to achieve a sense of oneness (Qin & Beauchemin, 2022). All students must feel connected, and their full identity valued with the teacher and one another. Creating a safe and inviting space is vitally important for a classroom learning environment (Venkatesamy, Sing, & Smart, 2020). In a diverse area it is important to cultivate to students a sense of belonging. To this end, the teachers should be educated on how to create classes that embrace the multicultural identities

of students and avoid students' feeling that they must assimilate (Mastrotheodoros et al., 2021). This could be achieved by including, for instance, classroom materials, such as literature or prompts representing students' diverse culture and languages. However, teachers' competence in promoting students' overall social and emotional growth is crucial to improve relationships between students as well as academic outcomes. Thus, they would benefit from training seminars in applying Social-Emotional Learning (SEL) programs and interventions that encourage the healthy social, emotional, and academic development of students of all ages and backgrounds with long-term effects (Kim-Ju, Knifsend, & Gonzales, 2024; Taylor, Oberle, Durlak, & Weissberg, 2017). Importantly, there is recent encouraging evidence that SEL benefits students from diverse backgrounds (Lee, Shapiro, & Kim, 2023).

International research suggests that teacher training in general - including effective teaching methodologies - positively influences student engagement and academic achievement (Hafeez, 2021). However, teacher training in multilingual and multicultural education plays a crucial role in shaping student outcomes. The implementation of multicultural education fosters cultural sensitivity, encourages students to examine different perspectives, and promotes self-reflection on biases. This, in turn, supports open communication, collaboration, and compassion among peers. However, the success of multicultural education heavily depends on teachers' ability to implement it effectively, highlighting the necessity of proper training (Latif Naz, Afzal, & Khan, 2023). Multicultural education enhances student engagement and academic achievement by recognizing and valuing diverse backgrounds, fostering positive relationships, and cultivating a sense of belonging and well-being (Caingcoy, 2023). Studies conducted with university students further indicate that multicultural education strengthens communication skills, cultural awareness, and overall well-being. However, inadequate teacher training can hinder its effectiveness (Taihe & Tahir, 2024). While existing research underscores the significant benefits of multicultural education for students, further studies are needed to explore the direct impact of teacher training on student learning experiences, well-being, and long-term academic success. Ultimately, though, the success of multicultural education largely depends on teachers' ability to implement its principles effectively.

The findings of the current pilot study suggest that teachers are aware of the various challenges that multilingual and multicultural students face at schools of Athens with high concentration of diverse population. Teachers also reported having knowledge of strategies for working with diverse students. These two aspects were positively correlated indicating that the higher the awareness, the better the knowledge of these strategies, which implies that awareness raising would also improve the knowledge of strategies that teachers employ. Despite the reported understanding of the challenges that students face and the strategies that could be used, teachers expressed the need to be further supported and trained in multicultural education through seminars and resources. The seminars could be focused on practical ways to incorporate students' language both in class and as a way to engage in meaningful interaction with students' families. C(L)RT training would help address teacher's concerns about the implementation of multicultural education and improve academic and developmental outcomes for students. These and more issues should be addressed in future research as the influx of immigrants and refugees is likely to increase in the years to come, the call for the Greek as well as all schools to be truly inclusive and multicultural will be imminent, and the need for teacher training in multicultural education will become pressing.

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APPENDIX I

Teacher survey:

Tick the appropriate box **Are you?** ☐ Male ☐ Female

Ethnicity: Age:

Please indicate your level of understanding and skill using the scale:

1 = extremely low; 2 = moderately low; 3 = low; 4 = high; 5 = moderately high; 6 = extremely high

- | | | | | | | |
|--|---|---|---|---|---|---|
| 1. How people learn a second language? | 1 | 2 | 3 | 4 | 5 | 6 |
| 2. How language influences learning? | 1 | 2 | 3 | 4 | 5 | 6 |
| 3. The nature of academic Finnish and the challenges it poses for multilingual learners? | 1 | 2 | 3 | 4 | 5 | 6 |
| 4. How culture influences learning? | 1 | 2 | 3 | 4 | 5 | 6 |
| 5. Language variation and dialects? | 1 | 2 | 3 | 4 | 5 | 6 |
| 6. The differences between proficiency in oral language and in written language | 1 | 2 | 3 | 4 | 5 | 6 |

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- 7 How many students from backgrounds different from your own did you have in your elementary class while growing up?
.....
- 8 How many students from backgrounds different from your own did you have in your secondary school class while growing up?
.....
- 9 How many students from backgrounds different from your own did you have in your high school class while growing up?
.....
- 10 How many teachers from backgrounds different from your own did you have in school?
.....
- 11 If you had, please describe the subjects they taught (math, science, sports, etc):
.....
- 12 Have you had experience with people from backgrounds different from your own in authority besides school (e.g. church, work, volunteer groups, etc.)? If so, please describe:
.....
.....
- 13 Have you ever discussed racism or classism? If so, with whom are you comfortable discussing it? (Friends, family, academic classroom, anyone):
.....
- 14 Have you ever witnessed acts of racism in your life? If so, please describe:
.....
.....
.....

Teacher survey:

Tick the appropriate box **Are you?** Male Female

Tick the appropriate box **Are you?** ☐ Male ☐ Female

Ethnicity: Age:

Please indicate your level of understanding and skill using the scale:

1 = extremely low; 2 = moderately low; 3 = low; 4 = high; 5 = moderately high; 6 = extremely high

- | | | | | | | |
|---|---|---|---|---|---|---|
| 1. Strategies for learning about the cultural backgrounds of multilingual learners? | 1 | 2 | 3 | 4 | 5 | 6 |
| 2. Strategies for teaching academic content to multilingual learners? | 1 | 2 | 3 | 4 | 5 | 6 |
| 3. Assessing multilingual learners' academic abilities in a classroom setting? | 1 | 2 | 3 | 4 | 5 | 6 |
| 4. Being able to modify classroom instruction for multilingual learners? | 1 | 2 | 3 | 4 | 5 | 6 |

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- | | | | | | | |
|--|---|---|---|---|---|---|
| 5. Being able to access and link multilingual learners' prior knowledge and experience with new ideas and skills as part of instruction? | 1 | 2 | 3 | 4 | 5 | 6 |
| 6. Strategies for using students' native language and culture to enhance acquisition of academic English and grade level content? | 1 | 2 | 3 | 4 | 5 | 6 |

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- | | | | | | | |
|--|---|---|---|---|---|---|
| 7. The nature and purposes of different types of programs for multilingual learners? | 1 | 2 | 3 | 4 | 5 | 6 |
| 8. Strategies for reaching out to and working effectively with multilingual learners' parents/guardians? | 1 | 2 | 3 | 4 | 5 | 6 |
| 9. What do you think are the three most important things teachers can do to support multilingual learners in their classrooms? _____ | | | | | | |
| 10. What are three areas of concern you have in terms of working with multilingual learners effectively? _____ | | | | | | |
| 11. What three areas of professional development you would like to engage in to better support your work with multilingual learners? _____ | | | | | | |

[Source: Acquah et al. 2016]

APPENDIX II Demographics Questions

Gender: Woman Man Other

Ethnicity:

Age:

Do you have a teaching certificate? Yes / No

Years of experience:

Years of experience in Kypseli:

How many students are in your class?

Did you grow up in:

1. Thessaloniki / Athens
2. A smaller city
3. A village

How many students in your class have:

1. Fully Greek heritage
2. Half Greek heritage
3. Fully other heritage

How many total nationalities are represented in your class?

More specifically, how many students are from:

1. Africa _____
2. Middle East (Turkey, Syria, Afghanistan, Iran, Iraq, etc) _____
3. Other Asian country: _____
4. Roma background _____
5. Albania _____
6. Ukraine _____
7. Romania _____
8. South America _____
9. Other European country: _____
10. Other non-European country _____

Chapter # 16

REFLECTIONS IN ACCELERATION: How GenAI Technologies Impact Educational Practice

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ABSTRACT

In an accelerating world where generative artificial intelligence (GenAI) significantly influences the daily operations of education, it is pertinent to discuss how this format can be integrated to balance and support students in working reflectively with the complex array of available knowledge and its interconnections. This chapter will explore the future of education through the lens of reflective practice learning, proposing how higher education can be reimagined to embrace GenAI as an opportunity to develop reflective competence. The discussion is grounded in Hartmut Rosa's (2021) mapping of the accelerating society, Donald Schön's work on reflection and learning (1991; 1990), and Hannah Arendt's elaboration on professional judgment. The chapter argues that future education must increasingly support the development of students' ability to learn how to learn and their capacity to critically reflect in their qualification of actions.

Keywords: reflection, learning, professional judgment, higher education, technology.

1. INTRODUCTION

The advent of GenAI in education marks a significant shift in the landscape of teaching and learning. GenAI's capacity to create original content, as defined by Gao, López-Pérez, Melero-Polo, and Trifu (2024), demonstrates a potential for both enriching and complicating educational practices. GenAI refers to systems that can create new, original content such as images, text, video, or music by learning patterns from existing data. Danish policy document highlights the need to adopt these new technologies and accelerate the speed of technological development and implementations to increase productivity and rethink workflow (Vestergaard, 2021). Thus, higher education is facing disruption created by generative AI, challenging existing teaching and learning practices and pedagogical values, while simultaneously adding promising resources. On the one hand, GenAI can transform education by opening new avenues for creativity, personalization, and access to knowledge by providing endless opportunities for adjustable knowledge. Yet it also introduces new demands on students and educators to navigate ethical considerations, critical judgment, and the potential impact of accelerated technology on human experience (Upadhyaya & Vrinda, 2021). According to Gao et al. (2024), GenAI is already transforming our education system by giving students the opportunity to condense knowledge and get help with writing processes through formulations and condensations of texts, etc. This places new demands not only on educators but also on students. Using GenAI in education requires both students and educators to develop critical reflection and judgment to evaluate information from GenAI. This includes consideration of ethical and moral issues. Students need to be able to assess the reliability and relevance of information in their learning processes. However, some students face technostress characterized by invasion, overload, complexity, uncertainty, and insecurity

in relation to the technological competence demands and demand for productivity, which can be seen as a part of the accelerating society (Rosa, 2021).

Reflection, judgment, and ethical awareness are essential skills in a world transformed by GenAI and rapid technological advancements, as they enable students to navigate the increasing complexity of knowledge. GenAI introduces an increased amount of information and new ways of interacting with knowledge, yet it also brings challenges around reliability, relevance, and ethical considerations.

It is, therefore, important that the student develops both professional judgment on a practical level as well as an ethical and reflective awareness on a metacognitive level. Arendt addresses this duality in her work on the human condition (1963) through the concept of *vita activa* and *vita contemplativa*. *Vita activa* centers on interactions and is an action-oriented judgment between people that creates new beginnings and shapes society. In an educational context, *vita activa* refers to the social dimension of learning—debates, discussions, and collaboration among students and educators where technological acceleration and societal disruptions from GenAI can either enhance or reduce human interaction and actions (Arendt, 1963). The concept of *vita contemplativa* is opposite to *vita activa* as it focuses on thinking and reflection as an inner process of thought aimed at understanding deeper truths and philosophical insights (Arendt, 1958; Arendt, 1963).

In times of continuous accelerations and disruptions, when it comes to emerging technologies, advantages in knowledge production, and changes in society, it becomes essential to look at how new technologies change the learning processes and the duality of *vita activa* and *vita contemplativa* (Biesta, 2021; Rosa 2021). Contemporary studies on educational practice address these perspectives and point to the need to foster a critical reflection among higher education students in relation to AI (e.g., McGuire, 2023, Walter, 2024; Oliveira, 2024). To address the challenges posed by rapid technological acceleration and societal disruptions from GenAI, this chapter draws on a pedagogical approach rooted in reflective practice-based learning (RPL). RPL is an educational model rooted in experience-based, pragmatic philosophies, drawing on thinkers such as Schön and Dewey (Dewey 1938; Horn et al., 2020; Bundgaard, 2024). By developing reflection, critical judgment, and ethical awareness through RPL, students are better prepared to engage meaningfully in their educational and professional landscapes, enabling them to thrive in rapidly evolving, ethically complex environments.

This brings us to the central research question of this chapter, which aims to investigate how reflective practice and professional judgment can contribute to sustainable and qualified learning processes in an accelerating digital society. As GenAI continues to reshape both the tools and methods of learning, educational practices must evolve to foster critical reflection and professional judgment among students, enabling them to navigate the ethical and cognitive challenges introduced by new technologies. By examining these themes through the framework of RPL, this chapter seeks to address the dual objectives of equipping students with reflective skills while fostering an ethically grounded educational environment.

How can reflective practice and professional judgment enhance sustainable and qualified educational practices in the context of an accelerating digital society influenced by generative artificial intelligence?

This question allows for an exploration of how reflective practice and professional judgment not only foster critical skills necessary for navigating the complexities of GenAI in education but also contribute to developing sustainable educational practices that adapt to the rapidly changing digital landscape.

2. REFLECTIVE PRACTICE AND PROFESSIONAL JUDGMENT

Arendt's ideas highlight the need for both active engagement and reflective thought within education, framing the discussion around how students can navigate accelerated technological and social changes. Schön's concept of reflective practice complements Arendt's framework by providing practical tools for developing judgment, adaptability, and critical reflection within the *vita activa* and *vita contemplativa*. Schön defines reflection as a critical process for professionals to improve their practice by combining experience, thinking, and action, and divides reflection into two types of reflection: reflection-in-action and reflection-on-action (Schön, 1991). By incorporating Schön's idea of reflection-in-action and reflection-on-action, this section explores how students can meaningfully bridge theory and practice and enhance their capacity to act thoughtfully to AI-generated content. Schön's model thus fills out Arendt's framework, adding a structured approach for fostering critical thinking and ethical awareness that enables students to engage deeply with their learning processes and respond with professional judgment to ongoing change.

2.1. Reflection-In- and On-Action

When trying to qualify judgment and create stepping stones for lifelong learning within higher education, it is relevant to become aware of how this can be supported through education. To work with students' awareness of their own learning and development, Donald Schön's concept of *deutero-learning*, which emphasizes the importance of learning to learn, is introduced. In higher education, this concept brings a metacognitive focus on the ability to improve one's own learning process through reflection (Schön, 1991). From this perspective, higher education must not only focus on the knowledge base of the profession but also work with a didactic framework that helps students learn to reflect and become curious about their own ways of learning. Here, the combination of theoretical thinking and practical action, which can be approached through reflection-in-action and reflection-on-action, is essential. By working with the temporal displacement of the relationship between action and reflection, it is possible to adapt and qualify actions. This process opens the exploration of professional practice through actions involving experimentation and improvisation, which supports critical reflection on the given profession. Thus, reflection from this understanding opens for the development and deeper understanding of practice (Schön, 1990). These elements combine to create an educational model that not only focuses on transferring knowledge but also on developing students' ability to think critically and reflect on their own practice.

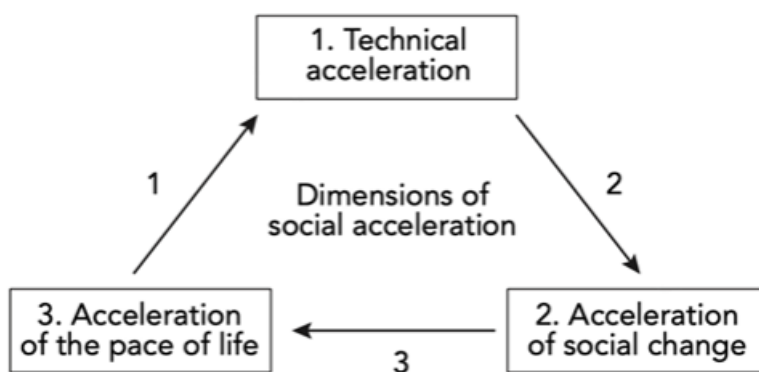
In the highly accelerated society characterized by high complexity and rapid change, it perhaps makes more sense than ever to incorporate reflection as an opportunity to give actions and experiences space. Schön's perspective on reflection is based on the idea that the education of professionals must emulate and reflect creative learning environments where students work closely with professional practitioners. Furthermore, higher education must support social learning communities where students can share experiences and learn from each other's questions (Schön, 1990).

2.2. The Accelerating Society

When we connect these concepts to Hartmut Rosa's resonance theory, which focuses on the quality of relationships and experiences in our lives, we can see how reflection and resonance can enrich each other (Rosa, 2021). Resonance involves a deep connection and mutual influence between the individual and the world, which can foster more meaningful reflection and thus deeper learning.

For the future of professional education, the integration of Schön's and Rosa's theories is crucial. By promoting a resonant practice where RPL is a central element, educational programs can create learning environments that support continuous development and adaptation. This will not only enhance students' professional competencies but also their ability to navigate and thrive in a complex and ever-changing world. Rosa (2013, p. 97) stresses that human beings in the world have fundamentally changed due to technological acceleration, coupled with an eagerness to accelerate profit and capitalism, making time akin to money (*ibid.*, p. 309). Rosa (2013, p. 156) illustrates the interplay between technical acceleration, acceleration of social change, and acceleration of the pace of life as dimensions of social acceleration, illustrated in Figure 1 below.

Figure 1.
The interplay between dimensions of social acceleration, retrieved from Rosa (2013, p. 153).



Students in higher education face the pressure of performing well to meet the expectations of society and thus their own ambitions. Higher education becomes subject to these pressures, and students' academic life at the campus has become an arena for these accelerations (Zapp, Marques, & Powell, 2021), aiming at producing skilled work-ready graduates. The focus on producing skilled, work-ready graduates places students in an environment that often mirrors the rapid pace of technological, social, and cultural change. In the following, the above model will serve as a guideline for insights into higher education from the perspective of reflective practice, combined with Schön's perspectives on educating the reflective practitioner as a socially conditioned process. This pressure underscores the importance of Schön's perspective on educating the reflective practitioner. His approach views reflection as a socially conditioned process, emphasizing the integration of theory and practice through critical reflection.

2.3. The Role of Technology

The rapid evolution of technology over the past 30 years is unmatched in human history. This evolution has increased demands on the workforce, reshaping the educational landscape. Workers are now expected to navigate complex, rapidly changing technological environments, making lifelong learning and skill acquisition essential. Educational systems must adapt to these realities by preparing students not only with foundational knowledge but also with the ability to continuously learn and remain relevant in their fields.

By situating Schön's reflective practice within Rosa's framework of resonance and social acceleration, we can better understand how to address these challenges. The increasing complexity of the modern world demands an education system that fosters reflection, critical thinking, and adaptability—skills that are vital for navigating the accelerated pace of contemporary life. Integrating Schön's and Rosa's theories offers a pathway to develop professional education programs that align with the demands of an accelerating society. This approach focuses on reflection as an opportunity to explore the combination of theory and practice and to engage in critical reflection.

3. ANALYSIS AND DISCUSSION

According to Rosa (2021), society's acceleration processes and performance pressures can cause individuals to feel alienated. The technological acceleration through GenAI can lead to a feeling of alienation. When technology takes over tasks that previously required human thinking and critical reflection, students may feel that they lose the ability to analyze and understand complex issues and reflect on their own actions. The alienation in education through GenAI thus points to a need for a balance between technological use and human judgment to maintain a meaningful and engaging learning process. The use of GenAI as part of education can create a sense of alienation for the individual, leaving them feeling detached from the world and themselves. To meet the challenges of the 21st century, students need to be empowered and feel that they can help create a world of well-being and sustainability—both for themselves and for others (OECD, 2023). It is therefore necessary to support a sense of resonance by ensuring that GenAI is used to support, rather than replace, meaningful relationships between educators and students.

If we consider GenAI as an opportunity for practice and reflection, we position it as a chance for further exploration of specific theories or ideals within the profession, or as an additional qualification and exploration of concrete courses of action (Schön, 1990). In this context, GenAI can serve to combine complex forms of knowledge, which imposes new demands on students to be critically reflective and evaluative. Adopting this perspective places different demands on educators' work with learning, and it opens a broader view of students' ability to reflect on how they arrived at their results or how they, by examining practical dilemmas, combine theory as a basis for qualifying actions. Thus, the technical acceleration is seen as an opportunity to delve into the evaluative and reflective aspects rather than the acquisition process, which has been the focal point of taxonomic thinking and evaluation of learning that dominates education worldwide (e.g., Biggs & Collis, 1982).

If we focus on the acceleration of societal change as a way of approaching the understanding of future higher education, it will in this context necessitate a dynamic relationship between theory and practice, where experiential learning tests and refines theoretical frameworks, ensuring that both remain relevant and responsive to evolving societal contexts. Again, this perspective demands a focus on how we incorporate space for reflection and professional judgment within the didactical frameworks as well as in the assessment of the students learning. The acceleration of social change compels critical thinking to adapt theoretical frameworks to new realities, ensuring that theory effectively informs practice in response to rapidly evolving societal dynamics.

3.1. Reflection-in-Action in Vita Activa

Schön's perspective on reflection is based on the idea that the education of professionals must emulate and reflect creative learning environments where students work closely with professional practitioners. Vita activa concerns interactions among people that

create new beginnings and shape society through different kinds of action. It involves the development of knowledge and skills that endure over time. *Vita activa* refers to the daily academic task students perform to maintain their learning and understanding. GenAI here can be seen as a tool that streamlines and automatizes routine tasks, such as by performing quick information searches, text rephrasing and summarization, or automating repetitive learning activities. In the highly accelerated society based on GenAI, students need to incorporate reflection-in-action to develop knowledge, theories, or products that have lasting significance and contribute to a broader intellectual or cultural landscape based on these daily academic routine tasks. This could be a well-developed analysis, thorough research, or a creative solution to a complex problem. In this process, AI can serve as a valuable tool, assisting students in refining their work by organizing and analyzing large amounts of data and literature that would otherwise demand significant resources and time.

Schön's perspective on reflection is based on the idea that the education of professionals must emulate and reflect creative learning environments where students work closely with professional practitioners. Furthermore, higher education must support social learning communities where students can share experiences and learn from each other's questions (Schön, 1990). Debates, discussions, and collaboration among students and educators are a part of *vita activa*.

Action in *vita activa* is tied to freedom and individuality as it is through social learning communities that people reveal their unique identities and contribute to the public sphere with knowledge, products, or thoughts (Arendt, 1963; Yarbrough & Stern, 1981). GenAI can enhance these social learning communities by promoting new forms of collaboration and idea exchange through digital platforms. On the other hand, an excessive reliance on GenAI may reduce human interaction and thus weaken the unique element of a shared human reflection-in-action (Arendt, 1963). When we connect these perspectives to Hartmut Rosa's resonance theory, which focuses on the quality of relationships and experiences in our lives, we can see how reflection and resonance can enrich each other in *vita activa* (Rosa, 2021). Resonance involves a deep connection and mutual influence between the individual and the world, which can foster more meaningful reflection and thus deeper learning. Through professional judgment, it is essential to ensure that technology acts as a tool for intellectual and personal growth rather than replacing critical thinking and creativity. By fostering reflection-in-action and embedding it within social learning communities, education systems can support students in navigating the complexities of accelerated digital environments while preserving the freedom, individuality, and meaningful engagement central to Arendt's *vita activa*.

3.2. Temporal Displacement in Vita Contemplativa

Technological acceleration and societal disruptions from GenAI have the potential to support the contemplative life by providing students with more time for deeper reflection when certain learning processes are automated. However, there is a risk that these technologies might replace or diminish the necessary human reflection if students rely too heavily on technology to perform tasks without critically engaging with the material themselves. This could lead to a superficial understanding of academic content, reducing the contemplative element in learning (Arendt, 2005; Yarbrough & Stern, 1981). These tendencies call for attention to the pedagogical practice in higher education and how it becomes necessary to not only focus on the knowledge base of the profession but also work with a didactic framework that helps students learn to reflect and become curious about their own ways of learning. Here, the combination of theoretical thinking in *vita contemplativa*

and practical action in *vita activa* can be approached through Schön's notion of reflection-in-action and reflection-on-action.

By working with the temporal displacement of the relationship between reflection-in-action and reflection-on-action, it is possible to adapt and qualify the student learning process within *vita contemplativa* and to support the development of a reflective mindset that supports the balance in the acceleration of the pace of life. If GenAI supports the student in routine tasks and daily academic tasks, it will free up time and mental resources that can be used to create a temporal displacement in the student learning process. Thus, the use of GenAI becomes the tool for strengthening *vita contemplativa* with the purpose of reaching deeper learning where students not only complete tasks but also reflect on their significance, ask questions, and explore complex theoretical issues. With this understanding, it is important that pedagogical considerations aim to create a balance between *vita activa* and *vita contemplativa*. The introduction of GenAI in the educational sector can thus be viewed as an opportunity to revitalize the contemplative life in academic settings, by recognizing and utilizing GenAI's potential to ease the workload and promote deeper reflection.

4. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The advent of GenAI in education marks a significant shift in the landscape of teaching and learning where the goal is to maintain an educational model that not only focuses on transferring knowledge but also develops students' ability to think critically and reflect to develop a nuanced understanding of their field. Additionally, value-based perspectives on how algorithms and AI-created experiences transform teaching and student learning processes are relevant and need to be addressed in future empirical research. By establishing a trust-based alignment of expectations for AI use, a more authentic learning experience can be promoted. Furthermore, transparency plays a key role in building trust between students and educators in relation to the use of GenAI.

Applying different theoretical perspectives adds a nuanced understanding of how reflective practice and professional judgment enhance sustainable and qualified educational practices in the context of an accelerating digital society influenced by generative artificial intelligence.

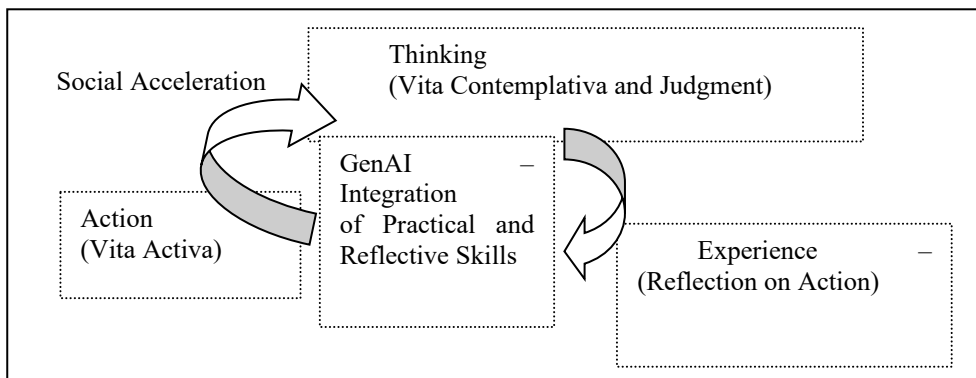
- **Reflective Practice:** Emphasizes the need for students to engage in reflection-in-action and reflection-on-action to bridge theory and practice, enhancing their capacity to act thoughtfully in response to AI-generated content
- **Professional Judgment:** Highlights the importance of developing students' ability to critically evaluate and ethically engage with information provided by GenAI
- **Social Acceleration:** Discusses the pressures of technological and social acceleration on students and the need for educational practices that support meaningful reflection and resonance
- **Vita activa and vita contemplativa:** Explores the balance between action-oriented learning (*vita activa*) and reflective, contemplative learning (*vita contemplativa*) in the context of GenAI

This chapter thus argues that it is important to understand how AI-based teaching becomes a balance between practical, often routine tasks and deeper reflection. When students use GenAI to handle routine tasks such as information retrieval, text reformulation, and data analysis, it frees up time and mental resources, allowing them to engage in reflection and critical thinking. Thus, GenAI can be the means to create a reflective space where the

students can delve more deeply into the contemplative side of learning. In this way of thinking, AI becomes not only a tool for easing the workload in *vita activa* but also a support for *vita contemplativa*. This balance between *vita activa* and *vita contemplativa* emphasizes the importance of educational institutions focusing not only on productive work but also on creating opportunities for reflection and deeper understanding. In this context, AI's role is not only to optimize practical tasks but also to support a deeper intellectual engagement, which places demands on the didactic framework for AI usage. The findings highlight the importance of integrating GenAI in education to balance and support students in developing critical reflection and ethical awareness. The study draws on Hartmut Rosa's theory of social acceleration, Donald Schön's reflective practice, and Hannah Arendt's concepts of *vita activa* and *vita contemplativa* to propose a pedagogical framework that fosters both practical and reflective skills.

Based on the findings from the discussion, a framework for sustainable educational practice has been developed to support higher education in embracing new technologies and combining experience, thinking, and actions inspired by the foundation of RPL. Figure 2 below illustrates how technologies such as generative AI must be embraced but also in the interplay between testing it out (action), professional judgment of the use of gen AI and the ethical implications (thinking) and reflection on the experience gained through actions (experience). The integration of practical and reflective skills must be added to give students the ability to gain AI literacy skills based on experimentation, testing, thinking experiences, and experiences, thereby allowing them to embrace the technology in a proper manner despite the different dimensions of social acceleration.

Figure 2.
A conceptual framework for sustainable and qualified educational practices when integrating reflective and practical skills in embracing generative AI.



The framework illustrated in Figure 2 can act as a foundation for working with any technological or practical disruption in higher education, replacing the content of matter in the middle of the figure. The conceptual framework also illustrates the need for both thinking and action and prior experience in interplay, meaning that only embracing one of the dimensions will not be sufficient in meeting the need for proper and ethical navigation in a society under continuous technological and social acceleration.

However, further empirical studies are needed to support the evidence of the conceptual framework in different higher educations.

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Chapter # 17

STRATEGIES FOR DEVELOPING MATHEMATICS AND SCIENCE RESILIENCE IN PRE-SERVICE TEACHERS TO ADDRESS MATHS AND SCIENCE ANXIETY IN SOUTH AFRICAN SCHOOLS

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ABSTRACT

This chapter explores strategies to foster resilience among pre-service mathematics and science teachers education to reduce maths and science anxiety within South African schools. Pre-service teachers often face high levels of maths-science-related anxiety, which can impact their effectiveness and confidence in teaching these subjects. Developing resilience is crucial to helping them cope with the challenges of teaching. This project examines various resilience-building strategies and practical teaching experiences and the integration of anxiety-reducing techniques within teacher training curricula for mathematics and sciences. The Self-Determination Theory underpins this study. The study employs a participatory action research approach, collecting qualitative insights from focus group interviews and reflective journals. This study employed action research to design cycles of whole class (n=29) intervention based on three tools designed by Johnson-Wilder and the mathematical resilience network team, and the emotional grid to support pre-service teachers in building resilience in math/science as they prepare for fieldwork. Data was analysed through thematic content analysis. The findings revealed that maths/science anxiety may be successfully reduced through the effective use of emotional tools. These findings suggest a new method of utilising the affective domain in teachers' training in South Africa for educational transformation.

Keywords: resilience, maths anxiety, science anxiety, pre-service teachers, teacher education.

1. INTRODUCTION

Education systems globally face the challenge of preparing future teachers to navigate the complexities of teaching mathematics and science effectively, particularly in contexts where anxiety towards these subjects among both students persists (Fitriati, Rosli, Iksan, & Hidayat, 2024; Wallace, 2015). In South Africa, as in many parts of the world, the effective teaching and learning of mathematics and science are crucial for developing a skilled workforce and a scientifically literate society (Jojo, 2019; Lelliott, 2014). However, despite efforts to improve educational outcomes in these subjects, challenges persist, particularly regarding pre-service teachers' (PSSTs) preparedness to teach mathematics and science effectively. One significant barrier to successful teaching and learning in these disciplines is the prevalence of math and science anxiety among students and teachers (Griggs, Rimm-Kaufman, Merritt, & Patton, 2013; Megreya, Szűcs, & Moustafa, 2021). In South Africa, where mathematics and science education outcomes have long been a concern (Reddy et al., 2020), addressing the anxiety levels associated with these subjects is paramount for enhancing teaching and learning experiences. Pre-service teacher education

programs play a crucial role in shaping teachers' competencies and attitudes towards mathematics and science instruction. However, there is a need to ensure that these programs not only equip future teachers with subject knowledge but also foster resilience to confront challenges inherent in teaching these subjects.

Mathematics and science anxiety, characterized by feelings of fear, tension, and apprehension when engaging with mathematical and science concepts, can significantly impede academic performance and professional efficacy. PSSTs who experience high levels of anxiety in mathematics and science may struggle to convey these subjects effectively in classrooms, perpetuating a cycle of anxiety and underachievement among students (Gresham, 2018). Addressing math and science anxiety among PSSTs is therefore paramount for enhancing the quality of mathematics and science education in South African schools. Moreover, cultivating resilience in PSSTs can empower them to navigate the challenges associated with teaching these subjects, fostering confidence and effectiveness in the classroom. This study investigates strategies for developing resilience among PSSTs while simultaneously addressing mathematics and science anxiety levels in South African schools. By exploring the intersection of resilience development and anxiety mitigation within the context of pre-service teacher education, this study seeks to contribute insights into effective pedagogical approaches and support mechanisms for preparing teachers to excel in teaching mathematics and science.

The following research question guides the study:

- (1) How do resilience-building strategies impact pre-service teachers' confidence and anxiety levels in mathematics and science as they prepare for teaching in South African schools?

2. BACKGROUND

Mathematics anxiety and science anxiety are two distinct yet interrelated phenomena that significantly impact students' academic performance and engagement in STEM (Science, Technology, Engineering, and Mathematics) fields. Both forms of anxiety manifest as feelings of tension, apprehension, and fear related to the respective subjects, but they arise from different contexts and can affect students in unique ways. Math anxiety is defined as a feeling of tension and apprehension that interferes with math performance ability, the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations (Khasawneh, Gosling, & Williams, 2021). Mathematics anxiety is characterized by a fear of performing mathematical tasks, leading to avoidance behaviours and a lack of confidence in one's mathematical abilities (Sokolowski & Ansari, 2017). This anxiety can stem from various sources, including negative past experiences with mathematics, societal stereotypes, and the high-stakes nature of math assessments. Studies indicate that mathematics anxiety is prevalent among students and can negatively correlate with their self-efficacy and performance in mathematics (Megreya & Al-Emadi, 2024; Megreya, Hassanein, Al-Emadi, & Szűcs, 2025). For instance, Daker, Gattas, Sokolowski, Green, and Lyons, (2021) found that first-year students' math anxiety predicted their avoidance of STEM fields and underperformance throughout their university studies, independent of their actual math ability. This suggests that even students who possess the necessary skills may refrain from pursuing STEM careers due to debilitating anxiety. Conversely, science anxiety refers to the apprehension and stress associated with learning and performing science-related tasks. Fia, Ayarkwa, and Obuobi-Ayim (2022) defined science anxiety as emotions that obstruct students' interest and engagement in scientific learning, ultimately hindering their scientific skills and knowledge development.

It encompasses a range of emotions, including fear of failure in scientific experiments, anxiety about understanding complex scientific concepts, and apprehension regarding participation in science classes. Avcı and Kırbaşlar (2017) highlighted that students' anxiety levels in science were significantly related to their academic performance, indicating that higher anxiety could lead to lower achievement in science subjects. While both mathematics and science anxiety share common features, such as the emotional distress associated with academic performance, they differ in their specific triggers and manifestations. The implications of these anxieties are profound, as they can lead to a cycle of avoidance and underachievement in both subjects. For instance, Megreya and Al-Emadi (2024) found that both math and science anxiety negatively correlated with students' self-efficacy in these domains, suggesting that anxiety can diminish students' confidence and willingness to engage with challenging material. This avoidance can further perpetuate feelings of inadequacy and reinforce negative beliefs about one's abilities in mathematics and science.

However, the emotional and psychological aspects contributing to mathematics and science anxiety are multifaceted, necessitating a comprehensive exploration of the underlying mechanisms that influence these feelings. Research indicates that mathematics anxiety is not merely a transient emotional response but a complex interplay of cognitive, emotional, and social factors that can significantly impact students' academic performance and career choices in STEM fields (Buckley, Reid, Goos, Lipp, & Thomson, 2016; Moustafa, Porter, & Megreya, 2019). Understanding these dimensions can provide educators and policymakers insights into effective interventions that can alleviate anxiety and foster resilience among pre-service teachers. Factors such as gender stereotypes and societal expectations can exacerbate feelings of inadequacy and anxiety, particularly among female students and those from underrepresented ethnic backgrounds (Pelch, 2018; Rozgonjuk, Kraav, Mikkor, Orav-Puurand, & Tähtet, 2020). Research has consistently shown that female students tend to report higher levels of mathematics anxiety compared to their male counterparts, which can be attributed to societal pressures and the internalization of negative stereotypes regarding their mathematical abilities (Pelch, 2018; Rozgonjuk et al., 2020). This highlights the need for educational interventions focusing on individual coping strategies and challenges and changing the broader cultural narratives surrounding mathematics/science and gender. In addition to cognitive and cultural factors, the emotional support systems available to students can significantly influence their experiences of anxiety. Research suggests that supportive teacher-student relationships can mitigate the effects of anxiety, fostering a positive learning environment that encourages risk-taking and resilience (Dowker, Sarkar, & Looi, 2016; McLean, Janssen, Espinoza, Johnson, & Jiménez, 2023). Teachers who model positive attitudes towards mathematics and provide constructive feedback can help students reframe their perceptions of mathematics as a subject that can be mastered with effort and practice rather than an insurmountable challenge (Dowker et al., 2016; McLean et al., 2023). Hence, Barroso et al. (2021) study supports the need for interventions to mitigate anxiety and enhance math/science achievement.

2.1. Theoretical Framework

Self-Determination Theory (SDT) (Ryan & Deci, 2018) offers a blueprint for understanding the motivational basis of personality and social behaviour and the relation of basic psychological needs to well-being, psychological flourishing, and high quality of life. SDT posits that three innate psychological needs motivate individuals to grow and change: autonomy, competence, and relatedness. These needs are crucial in fostering resilience,

especially in high-anxiety contexts such as learning challenging subjects. Research indicates that emotional intelligence, motivation, and resilience significantly influence academic performance and the adoption of healthy lifestyle habits among adolescents, which can be extrapolated to PSSTs (Trigueros, Cangas, Bermejo, García, & Liriaet, 2019). This connection underscores the importance of fostering emotional intelligence and motivation through SDT principles, thereby enhancing resilience. For instance, when PSSTs perceive their learning environment as supportive of their autonomy, they are more likely to engage deeply with the material, which can mitigate feelings of anxiety associated with learning mathematics and science. Moreover, the interplay between teacher resilience and professional development is critical. Studies have shown that supporting beginning teachers in addressing their specific needs can significantly contribute to their overall professional development (Kim, 2024). This suggests that interventions grounded in SDT could be tailored to enhance the resilience of PSSTs by providing them with opportunities to develop their competencies in a supportive environment. For example, creating collaborative learning experiences that foster relatedness among peers can enhance their sense of belonging and reduce anxiety. In addition, the motivational climate within educational settings plays a significant role in shaping PSSTs' engagement and resilience. Studies have shown that a positive motivational climate, characterized by supportive teaching styles, can enhance academic engagement and resilience among PSSTs (López-García, Poyatos, Burgueño, & Granero-Gallegos, 2022).

Competence refers to the feeling of being effective in one's activities. A strong sense of competence in mathematics and science education can significantly reduce anxiety and improve performance (Termizi & Mahmud, 2022). In this study, the interventions highlighted coping strategies that built competence through mastery experiences and highlighted the importance of practical teaching experiences in building confidence and reducing anxiety among PSSTs. The third component of SDT, relatedness, emphasizes the importance of social connections and support in the learning process. This study created a supportive learning community among PSSTs that nurtured them through classroom activities, thereby reducing feelings of isolation that often accompany anxiety. Research has shown that when students feel connected to their peers and instructors, they are more likely to engage in learning activities and persist in the face of challenges (Daker et al., 2021). Therefore, implementing collaborative learning strategies and peer support systems in teacher training programs can enhance relatedness and contribute to resilience against anxiety in mathematics and science.

2.2. Methodology

2.2.1. The Research Process and Analysis

The study employed a Participatory Action Research (PAR) approach to design a whole-class intervention (MacDonald, 2012). PAR allows for a high degree of participant engagement throughout the research process, promoting a sense of ownership and commitment among those involved (MacDonald, 2012). This study is an active collaboration of eight lecturers who teach Mathematics, Science and Technology. However, this chapter reports on interventions at one university where the Growth Zone Model (GZM), the Hand Model of the Brain (HMB) and Relaxation Response Model (RRM) tools (Johnston-Wilder, Lee, & Mackrell, 2021) were embedded into classroom practices to promote math and science resilience among third-year university students. The sample consists of one whole class of nineteen (19) males and ten (10) females. In the first cycle of interventions, a series of training sessions which were embedded into their physical

sciences teaching II curriculum were conducted for PSSTs, focusing on resilience-building strategies and addressing anxiety in teaching mathematics and science. These workshops helped PSSTs to identify anxiety triggers related to assessments and practice cognitive reappraisal techniques. For instance, before a major mathematics formal task, PSSTs participated in a session where they learned to replace thoughts like *I'm going to fail* with *This anxiety shows I care and am prepared to tackle the challenge*. Follow-up surveys indicated reduced exam-related anxiety. These sessions facilitate discussions and activities to enhance learning and teaching effectiveness and confidence in the subject they will teach in the future. At the same time, during physics III, chemistry III, and mathematics III content lessons, the lecturers engaged in a series of interventions with the three tools as PSSTs learned physics, chemistry, and mathematics concepts, usually beginning with brief mindfulness exercises, such as deep breathing or guided visualization, to create a calm, focused learning environment. For example, a chemistry lecturer incorporates a 3-minute breathing exercise before starting complex organic chemistry lessons.

All the tools were provided to the PSSTs for engagement purposes. PSSTs maintain a weekly reflection journal documenting their learning experiences, challenges, strategies to overcome difficulties, and personal growth insights. For instance, after a challenging lesson on chemical equilibrium, a pre-service teacher reflects on the misconceptions encountered and how reworking problems with peer support helped improve understanding. This process helps normalize struggles as part of the learning journey.

Qualitative data was collected at the end of the first semester through focus group discussions, reflective journals and individual interviews. The qualitative data was analysed using thematic analysis as guided by Clarke and Braun's (2016) framework. Quality assurance measures were established by returning the captured responses to the participants for member checking.

2.2.2. Research Findings

Participants Profile

The sample consists of 19 males and 10 females. All PSSTs were in their third year at the university, suggesting they have progressed through their academic program and were approaching the completion of their teacher education. While specific ages may vary, PSSTs in their third year at university typically range from early 20 years to 25 years, although there may be some variation due to individual circumstances. Each PSST brings unique strengths and qualities to the classroom, whether it be leadership abilities, subject matter expertise, creativity, or a passion for working with learners.

In discussing these findings within the framework of SDT, it becomes clear that interventions such as the GZM, HMB and RRM play a pivotal role in fulfilling three essential SDT needs: autonomy, competence, and relatedness, which are necessary for nurturing intrinsic motivation and resilience in learning mathematics and science. Three themes emerged in the data analysis: motivation for learning complex concepts, cultivating confidence and personality development all in relation to autonomy, confidence and relatedness.

Theme 1: Motivation for Learning Complex Concepts

SDT posits that individuals are more motivated to engage in activities when they feel competent, autonomous, and connected to others. Participants' reflections on the interventions highlight how these tools helped them manage anxiety and build confidence, a shift that aligns with increased competence, which is one of SDT's core needs. By recognizing and confronting their discomfort within the GZM framework, participants began to view math and science as areas for potential growth rather than fear, thereby

nurturing intrinsic motivation. For example, PSST9's recognition that growth lies outside their comfort zone is emblematic of SDT's emphasis on resilience through self-determined learning.

Some participants narrated:

I have struggled with anxiety in math and science for as long as I can remember. The Growth Zone Model has given me a framework to understand that it is okay to feel uncomfortable and that growth happens outside of my comfort zone. It is still a work in progress, but I am seeing improvements in my confidence and performance (PSST9).

For the first time in my life, I am no longer anxious when I have maths and science tests. I could not believe it when my lecturer announced test dates for Chemistry III and Mathematics III (PSST29).

Ah, indeed, the GZM has really helped me. I just move my pebbles to appropriate levels during lectures. That engages me actively in the lesson. When I am in my comfort zone, I begin to smile about myself and my achievements. I know within me that I can do this (PSST18).

Theme 2: Cultivating Confidence

The participants' increased confidence indicates a strengthened sense of competence fostered by the interventions. PSST1 reflective responses indicated exemplified shifts in self-perception, driven by repetitive affirmations that empower them to tackle complex content. This internal motivation for competence fosters resilience and positions them as proactive learners who will, in turn, inspire similar resilience in their future students. Furthermore, PSSTs' use of mindfulness techniques reflects SDT's emphasis on autonomy, as these strategies allow them to self-regulate and remain autonomously engaged in the learning process. Two PSSTs responded:

The interventions have improved my confidence in math/science. The thought of having "I can do maths" I can do chemistry" lingers in my mind each time the lecturers teach complex concepts. I keep saying this to myself to help me get through to each lesson. That has been helpful (PSST1).

My confidence in mathematics, chemistry and physics has improved drastically. Quantum mechanics at the third-year level was very challenging. Now, with the relaxation model, I can breathe in and breathe out as if I am releasing too much information out of my system so I can absorb more... hahaha. But now I'm very confident in myself (PSS4).

Incorporating mindfulness activities into math/science lessons helped PSSTs stay calm and focused on the task at hand. Techniques such as mindful breathing allowed them to approach math/science with a calm and centred mindset.

Theme 3: Personality Development

Through the use of GZM and related strategies, participants report personal growth and an anxiety reduction, embodying SDT's concept of relatedness, the idea that feeling connected to a community (in this case, through shared growth in resilience-building tools) enhances motivation. The GZM empowers participants like PSST20 and PSST15 by reframing discomfort as part of the learning journey, thus allowing them to see personal progress rather than focusing solely on achievement.

"I've been amazed by the impact of incorporating coping strategies based on the GZM, HMB, and RRM in our lectures. I have been empowered to approach science and mathematics with a growth mindset, knowing that my abilities are not fixed and that they can improve with effort and perseverance. As a result, I have seen a noticeable reduction in my anxiety levels and a corresponding increase in my academic achievement (PSST20).

The GZM has been a game-changer for me in tackling my anxiety around math and science. I understand that discomfort is a natural part of growth, and I've been able to push through challenging concepts with more confidence. It's not about being perfect but about progressing, and that mindset shift has made all the difference (PSST15).

2.3. Discussions

Mathematics and science anxiety can be significant barriers to effective teaching and learning among PSSTs. These anxieties not only impact the teachers themselves but also have cascading effects on the confidence and achievement of their future students. To address this issue, it is essential to explore strategies that not only reduce anxiety but also cultivate resilience and motivation in PSSTs towards these subjects. This explored how integrating intervention strategies using the GZM, the HMB and RRM vis-a-vis informed by the SDT can help reduce mathematics and science anxiety among PSSTs while simultaneously building their resilience towards these subjects. The SDT posits that when individual needs are satisfied, individuals experience greater intrinsic motivation, well-being, and optimal functioning. Applying the principles of SDT to the context of PSSTs facing mathematics and science anxiety offers a promising avenue for intervention, which improves students' learning and reduces anxieties as they work towards building resilience. The first theme focused on motivation to learn complex concepts in math and science. The study found that the participants believed that the tools helped alleviate their doubt and anxiety with mathematics and science as they studied complex concepts in the subjects. This finding aligns with the study by Barroso et al. (2021), who support the need for interventions to mitigate anxiety and enhance math/science achievement. The second theme focused on cultivating a sense of confidence as they build resilience. The study found that the interventions provided a starting point for their confidence in the subjects as they have developed knowledge of the subject with understanding and would be able to assist their future learners to develop confidence in mathematics and science. Research supports students' emotional well-being and resilience in science education. Some of its indicators include thinking patterns, self-confidence, having support, optimism, perseverance, and being able to have self-control in difficult situations (Hakim & Murtafiah, 2020; Johnston-Wilder et al., 2021). The third theme focused on participants' personality development. The findings show that implementing coping strategies based on the intervention models has been incredibly effective in helping PSSTs manage anxiety in science and mathematics. SDT highlights the significance of intrinsic motivation, autonomy, and competence in fostering positive outcomes in educational settings (Johnston-Wilder et al., 2021). Following a cycle of interventions, PSSTs can effectively integrate the GZM, HMB, and RRM into their teaching practice to reduce anxiety in science and mathematics topics and build resilience in these subjects.

Although studies have shown that gender differences, ethnicity, and socioeconomic status significantly influence how individuals experience and manage anxiety (Li et al., 2023; Skagerlund, Östergren, Västfjäll, & Träff, 2019; Zhang, Zhao, & Kong, 2019), it becomes evident that resilience strategies cannot adopt a one-size-fits-all approach. Instead, instructions must be specifically tailored to address different demographic groups' distinct challenges. In light of this, incorporating resilience strategies that build confidence and foster supportive mentorship is crucial for PSSTs. Research highlights that reflective practices that encourage self-awareness and personal growth, alongside peer support networks, can also significantly alleviate anxiety (Prachagool, Nuangchalerm, Juhji, & Thavornsil, 2021). Such strategies help enhance the overall resilience of PSSTs, preparing them to navigate the challenges of their future teaching careers effectively.

While the sample size might limit the transferability of findings, it is sufficient to identify recurring themes and patterns relevant to the research objectives.

3. FUTURE RESEARCH DIRECTIONS

The long-term impact of this study would be the engagement of the PSSTs after they have entered the teaching profession, encouraging them to engage in reflective practices on how resilience strategies have helped them manage their anxiety in the classroom over time.

Future research could explore the long-term impact of resilience-building interventions, such as the GZM and RRModel, on PSSTs' efficacy in real classroom settings. Investigating how these tools influence their teaching practices over time would provide valuable insights into sustained effects on anxiety management and resilience. Resilience strategies could be integrated into long-term professional development programs. For example, including resilience-building modules in in-service teacher training or workshops after graduation could help assess if these strategies lead to continued teacher growth and lower anxiety levels during their careers. Further studies might examine the potential of integrating additional frameworks like SDT-based mentorship programs that foster autonomy, competence, and relatedness within teacher training curricula. Expanding this research to other educational contexts, such as early-career in-service teachers or secondary students, could offer a broader understanding of how resilience-building strategies reduce anxiety and promote confidence in STEM fields. Finally, future studies might analyze the role of cultural factors in South Africa that impact how PSSTs experience and respond to interventions to ensure these tools are culturally adaptive and effective in diverse settings.

4. CONCLUSION

This study explores strategies to enhance resilience and reduce anxiety levels among PSSTs in mathematics and science within the context of South African schools. An important issue emphasised in the study is the significance of reducing anxiety levels among PSSTs in mathematics and science. Moreover, the motivating climate in educational environments significantly influences PSSTs' engagement and resilience. Research indicates that a favourable motivational climate, defined by encouraging pedagogical approaches, might improve academic engagement and resilience in PSSTs (López-García et al., 2022). Using SDT principles, educators can cultivate an environment that enhances intrinsic motivation, promoting resilience in overcoming adversities.

Studies have demonstrated that anxiety may have a substantial effect on both the effectiveness of instruction and the academic achievements of students. Hence, it is important to implement interventions that target the reduction of anxiety levels and the enhancement of resilience in PSSTs to enhance educational practices and optimise student learning experiences. Nonetheless, the study recommends integrating experiential learning methodologies into teacher training programmes and implementing mentoring programmes and support structures that can foster resilience and mitigate anxiety levels among PSSTs. Through the provision of experienced mentors, resources, and advice, PSSTs can receive the necessary assistance to effectively negotiate the difficulties associated with teaching and learning mathematics and science.

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Chapter # 18

LEVERAGING ICT TOOLS FOR TEACHING AND LEARNING IN PHYSICAL SCIENCES

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ABSTRACT

This chapter examines the effective use of Information and Communication Technology (ICT) tools to enhance teaching and learning in physical sciences. By incorporating various ICT resources—such as simulations, virtual labs, and interactive multimedia—the chapter evaluates their impact on student engagement, comprehension, and academic achievement. Through a mixed methods approach, the study identifies optimal strategies for integrating ICT into pedagogical practices, particularly for deepening students' understanding of abstract scientific concepts. The study's findings reveal that ICT tools, such as simulations and interactive demonstrations, significantly improve students' grasp of complex concepts by providing visualizations and hands-on experiences. Participants reported increased engagement and comprehension, with ICT-enabled personalized learning allowing students to progress at their own pace and access supplementary materials. Despite these benefits, challenges persist, including limited access to technology, insufficient technical support, and concerns over digital equity. The chapter concludes by offering actionable insights for educators and policymakers seeking to enhance physical sciences education through ICT integration while addressing the systemic barriers that hinder equitable implementation in diverse educational contexts.

Keywords: ICT tools, teaching, learning, physical sciences, technology integration.

1. INTRODUCTION

In the contemporary educational landscape, the integration of Information and Communication Technology (ICT) tools has become a critical component of innovative teaching and learning practices. Within the physical sciences—spanning disciplines such as physics, chemistry, astronomy, and earth sciences—ICT tools offer unique opportunities to enhance students' understanding of complex concepts, foster engagement, and bridge the gap between theoretical knowledge and practical application (Sharma, Gupta, & Agarwal, 2023). Despite the increasing prevalence of ICT in education, there remains a pressing need to investigate its effectiveness in addressing persistent challenges in physical sciences education, such as making abstract concepts accessible and promoting active, inquiry-based learning (Coccia, 2020; Hajkowicz, Sanderson, Karimi, Bratanova, & Naughtin, 2023).

This study addresses the critical need to understand how ICT tools can be effectively utilized to overcome these challenges and maximize educational outcomes in physical sciences. By examining the pedagogical practices, technological applications, and barriers associated with ICT integration, this research seeks to provide actionable insights for educators and policymakers. The study investigates the diverse applications of ICT—ranging from interactive simulations and virtual laboratories to data visualization tools and collaborative platforms—highlighting their potential to enrich learning experiences. By focusing on the real-world experiences of educators and students, this research aims to

identify best practices and practical recommendations to optimize ICT-enhanced instruction in physical sciences education.

In addressing the evolving needs and challenges of physical sciences education in the digital age, this study contributes to the ongoing discourse on innovative pedagogical approaches and technology integration strategies. By illuminating the potential of ICT tools to transform teaching and learning practices in the domain of physical sciences, this research endeavors to inform curriculum development, instructional design, and professional development initiatives aimed at preparing students for success in an increasingly technology-driven world.

2. CONTEXTUALIZATION OF THE CHAPTER

In an era where technological advancements continue to reshape all facets of human activity, the field of education stands at the forefront of digital transformation. The chapter is situated within this evolving landscape, addressing the urgent need to integrate innovative digital practices into educational settings. Physical sciences, encompassing disciplines like physics, chemistry, astronomy, and earth sciences, rely heavily on empirical inquiry, data analysis, and theoretical modeling—areas where ICT tools can substantially enhance pedagogical effectiveness (Krauss, 2024). This chapter contextualizes the role of ICT tools as not merely supplementary aids but as fundamental components for enriching teaching and learning in these disciplines.

The integration of ICT in physical sciences education has gained traction due to its potential to bridge the gap between abstract concepts and practical understanding. Traditional teaching methodologies, often confined to textbook-driven instruction and theoretical discussions, can be limited in fostering deep, conceptual comprehension among students (Hu, 2024). ICT tools, including simulations, virtual laboratories, and interactive multimedia, offer dynamic, hands-on experiences that facilitate experiential learning (Haleem, Javaid, Qadri, & Suman, 2022). By engaging students in immersive, interactive activities, these tools enable them to visualize complex scientific phenomena, conduct virtual experiments, and access diverse data sets, thereby making abstract concepts tangible and accessible (Al-Ansi, Jaboob, Garad, & Al-Ansi, 2023).

Furthermore, the contextualization of this chapter emphasizes the relevance of addressing the pedagogical and logistical challenges that educators face when incorporating ICT into their teaching practices. Issues such as limited access to digital infrastructure, varying levels of digital literacy among teachers and students, and disparities in technological resources pose significant barriers to effective ICT integration (van de Werfhorst, Kessenich, & Geven, 2022). Recognizing these challenges is crucial for developing practical strategies that educators can implement to optimize the use of ICT tools. By delving into best practices, case studies, and evidence-based recommendations, the chapter aims to provide a comprehensive framework for leveraging ICT in a way that is inclusive, equitable, and adaptable to diverse educational contexts.

Additionally, this chapter situates its analysis within global educational trends, where there is a growing emphasis on personalized and student-centered learning experiences. ICT tools offer opportunities for differentiated instruction, allowing students to learn at their own pace and explore content that aligns with their individual interests and learning styles (Anghelo Josué et al., 2023). This approach is particularly significant in physical sciences, where the mastery of complex concepts often requires varying degrees of repetition, practice, and tailored instructional support.

By presenting a balanced discussion of both the potential benefits and the challenges of ICT integration, this chapter aims to inform not only educators and policymakers but also curriculum developers and researchers interested in the transformative potential of digital technologies in science education. Through a mixed methods approach, the chapter draws on qualitative insights from educators and students, as well as quantitative data on academic performance and engagement outcomes. This multi-faceted exploration provides a nuanced understanding of how ICT tools can be strategically leveraged to improve educational outcomes in physical sciences.

Ultimately, this chapter seeks to contribute to the broader discourse on educational innovation, emphasizing the importance of harnessing technology to promote active, inquiry-based learning and foster a deeper appreciation for the empirical nature of physical sciences. By contextualizing ICT as an essential element of modern pedagogy, the chapter aspires to advance the conversation on how to best prepare students for future scientific and technological challenges.

3. BACKGROUND

The rapid advancement of Information and Communication Technology (ICT) has dramatically reshaped educational practices across all disciplines, including the physical sciences. As digital technologies evolve, they offer new opportunities to enhance the teaching and learning process, moving beyond traditional pedagogical approaches to create more dynamic, interactive, and effective learning environments. In particular, the integration of ICT in science education is increasingly recognized as a powerful tool for improving student engagement, fostering deeper understanding, and enhancing academic achievement (Haleem et al., 2022). This shift aligns with broader global educational trends aimed at transforming teaching methods to better prepare students for the demands of the 21st century.

Physical sciences, encompassing disciplines like physics, chemistry, astronomy, and earth sciences, are often characterized by complex concepts and abstract theories that can be challenging for students to grasp. ICT tools, such as simulations, virtual laboratories, interactive multimedia, and digital learning platforms, offer valuable resources for bridging the gap between theory and practice. These tools provide students with opportunities to engage with scientific phenomena in ways that make abstract concepts more concrete and accessible, thus fostering a deeper level of comprehension (Alam & Mohanty, 2023). By incorporating ICT into physical sciences education, educators can create immersive learning experiences that allow students to experiment, observe, and manipulate scientific concepts in real-time, promoting a hands-on approach to learning that supports both conceptual understanding and practical skills development.

The shift toward ICT-enabled education reflects a broader movement in education reform, which emphasizes student-centered learning environments. ICT tools facilitate a personalized learning experience, allowing students to progress at their own pace, revisit challenging topics, and receive immediate feedback on their performance. Moreover, these tools provide opportunities for inquiry-based learning, a pedagogical approach that encourages students to explore, question, and critically analyze scientific concepts. Inquiry-based learning, supported by ICT, nurtures essential skills such as problem-solving, critical thinking, and independent learning—skills that are central to science education (Hinostroza, Armstrong-Gallegos, & Villafaena, 2024). The ability of ICT to enable students to engage with real-world scientific problems further enhances the relevance of physical sciences education in preparing students for future careers in science, technology, engineering, and mathematics (STEM) fields.

However, the integration of ICT in physical sciences education is not without its challenges. While the potential of ICT to enhance teaching and learning is clear, there are significant barriers to its widespread adoption. Issues related to digital equity, infrastructure limitations, and the need for adequate professional development for educators to effectively utilize ICT tools remain persistent concerns. Many schools, particularly those in under-resourced areas, face substantial obstacles in accessing the necessary technology and support, preventing students and educators from fully benefiting from ICT-enhanced instruction (Wang, Chen, Yu, Liu, & Jing, 2024). Furthermore, the fast pace of technological advancement requires educators to continuously adapt to new tools and platforms, posing additional challenges for both teachers and students. To ensure that ICT integration enhances rather than detracts from the learning experience, it is essential to develop strategies that address these barriers and optimize the use of technology in the classroom.

This chapter aims to provide a comprehensive analysis of the opportunities and challenges associated with leveraging ICT tools for teaching and learning in the physical sciences. By examining current pedagogical practices, reviewing empirical research, and exploring the diverse ICT tools available for physical sciences education, this chapter offers valuable insights for educators, policymakers, and stakeholders. The discussion will highlight best practices for integrating ICT into science curricula, provide recommendations for overcoming the challenges of ICT adoption, and propose strategies to ensure that technology enhances learning outcomes and promotes inclusivity in science education.

4. GAPS IN THE EXISTING LITERATURE

In the existing body of literature on Information and Communication Technology (ICT) integration in education, numerous studies have explored its transformative potential across various disciplines. However, there remain several significant gaps, particularly when it comes to its application in the context of physical sciences (Msafiri, Kangwa, & Cai, 2023). These gaps highlight areas where further research and exploration are essential for optimizing the use of ICT tools in enhancing teaching and learning in this field.

One of the key gaps in the literature is the limited context-specific research on the integration of ICT tools in physical sciences education (Fu, 2013). While many studies discuss ICT's potential in general terms, few focus on the unique demands and instructional needs of subjects like physics, chemistry, astronomy, and earth sciences (Mhlongo, Mbatha, Ramatsetse, & Dlamini, 2023). These disciplines often require specialized pedagogical strategies to convey abstract scientific concepts and foster empirical inquiry. Therefore, research that tailors ICT applications to the distinctive characteristics of physical sciences is lacking.

Another gap exists in the pedagogical frameworks for using ICT tools effectively in physical sciences classrooms (Mlambo, Rambe, & Schlebusch, 2020). While various ICT tools, such as simulations and virtual laboratories, have been identified as effective for enhancing student engagement, there is insufficient exploration of the pedagogical practices necessary to integrate these tools into physical sciences instruction (Hillmayr, Ziernwald, Reinhold, Hofer, & Reiss, 2020). Research has predominantly focused on the technological capabilities of these tools but often neglects how they can be strategically aligned with curriculum objectives, teaching methods, and assessment strategies (Lu & Xie, 2024). More research is needed to provide educators with practical guidance on how to leverage ICT tools to support inquiry-based, hands-on learning experiences in physical sciences.

Additionally, there is a lack of in-depth exploration of student-centered outcomes when using ICT tools in physical sciences (Dunbar & Yadav, 2022). Much of the existing literature

focuses on the technological aspects of ICT, but fewer studies examine how these tools influence critical aspects of student learning, such as conceptual understanding, problem-solving skills, and engagement in scientific inquiry (Lu & Xie, 2024). More research is needed to assess the impact of ICT tools on students' cognitive development and academic achievement in physical sciences, as well as to explore how these tools can facilitate personalized learning experiences.

The challenges and barriers associated with ICT integration in physical sciences education are another underexplored area. While the benefits of ICT are well-documented, there is insufficient attention paid to the practical obstacles educators face, such as limited access to digital infrastructure, gaps in digital literacy among students and teachers, and disparities in technological resources across different educational settings (Aruleba & Jere, 2022). These barriers must be better understood to develop effective strategies for overcoming them and ensuring equitable access to ICT tools for all students, regardless of their socio-economic background or geographical location.

Moreover, there is a noticeable underrepresentation of equity and accessibility issues in the literature on ICT in education (Stauber & Parreira do Amaral, 2015). The digital divide remains a significant concern, particularly in regions where access to technology is limited. While many studies emphasize the importance of ICT in enhancing education, few address how to ensure that all students have equal access to the digital resources necessary for effective learning (Haleem et al., 2022). More research is needed to investigate how to address these disparities and ensure that ICT tools are used to foster inclusive learning environments in physical sciences.

Empirical evidence on the effectiveness of ICT tools in physical sciences education is still relatively sparse. Many studies rely on theoretical discussions or anecdotal evidence to argue for the benefits of ICT, but there is a lack of robust, empirical research that quantifies the impact of ICT on student performance and engagement in physical sciences classrooms (Freling, Yang, Saini, Itani, & Abualsamh, 2020). Longitudinal studies that track the sustained effects of ICT integration on academic achievement and conceptual understanding are particularly lacking (Lei, Xiong, Chiu, Zhang, & Cai, 2021). There is a need for more data-driven research to validate the claims about the positive outcomes of ICT use in these disciplines.

Furthermore, there is a scarcity of research on emerging technologies like augmented reality (AR), virtual reality (VR), and artificial intelligence (AI) in physical sciences education (Vuta, 2021). While these tools hold immense potential for transforming how students interact with scientific concepts, there is limited research on their application in physical sciences classrooms (Anghelo Josué et al., 2023). Investigating how these cutting-edge technologies can be integrated into teaching and learning in subjects like physics and chemistry is crucial to keeping pace with technological advancements and meeting the evolving needs of 21st-century learners.

Lastly, the integration of ICT tools with inquiry-based and experimental learning approaches in physical sciences remains an underexplored area (Hinostroza et al., 2024). While ICT tools are widely used for simulations and virtual experiments, there is little research on how these tools can be used in tandem with hands-on, experimental learning in the classroom or laboratory (Rutten, van Joolingen, & van der Veen, 2012). Physical sciences education often relies on students engaging in real-world investigations and experiments to develop a deeper understanding of scientific principles (Oguoma, Jita, & Jita, 2019). More research is needed to explore how ICT tools can complement or enhance traditional experimental methods and facilitate deeper, more meaningful inquiry-based learning experiences.

By identifying these gaps, this chapter aims to address the overlooked areas in the literature and contribute new insights into how ICT tools can be leveraged to improve teaching and learning in the physical sciences. Filling these gaps will provide a more comprehensive understanding of the challenges and opportunities associated with ICT integration and will guide educators, researchers, and policymakers in optimizing the use of technology to enhance science education.

5. PROBLEM STATEMENT

The integration of Information and Communication Technology (ICT) into physical sciences education has the potential to revolutionize teaching and learning practices, offering innovative ways to engage students, enhance conceptual understanding, and foster critical thinking. However, despite the increasing adoption of ICT tools in various educational settings, significant challenges persist, particularly in the physical sciences domain (Ramafi, 2022). These challenges include the disparity in access to digital tools and infrastructure, the lack of adequate professional development for educators, and the difficulties in aligning ICT applications with pedagogical strategies that effectively promote student learning outcomes (Mhlongo et al., 2023). Moreover, while ICT tools such as simulations, virtual laboratories, and interactive multimedia have proven to enhance student engagement and comprehension, there is a need for deeper insights into how these tools can be optimally integrated into physical sciences curricula and the factors that hinder their widespread implementation (Haleem et al., 2022). As such, the gap between the potential benefits of ICT in science education and its actual impact on learning outcomes calls for focused research to understand the pedagogical, infrastructural, and technical barriers to effective ICT integration in the physical sciences.

This chapter aims to address the identified challenges and gaps in the existing literature by providing a comprehensive exploration of how ICT tools can be leveraged for teaching and learning in the physical sciences. The objectives of the chapter are as follows:

- To examine the potential of ICT tools to enhance teaching and learning in the physical sciences – This objective will explore how tools like simulations, virtual labs, and interactive multimedia can make abstract scientific concepts more accessible, facilitating deeper student engagement and understanding.
- To investigate the pedagogical strategies and practices employed by educators in ICT-integrated physical sciences classrooms – The chapter will analyze current approaches to using ICT in physical sciences instruction, identifying best practices and strategies for effective integration that promote inquiry-based learning and problem-solving skills.
- To identify the challenges and barriers faced by educators in the integration of ICT into physical sciences education – This objective will address issues such as digital equity, infrastructure limitations, and the need for professional development, exploring how these barriers impact the full adoption of ICT tools in the classroom.
- To provide recommendations for overcoming challenges and optimizing ICT use in physical sciences education – Based on the findings, the chapter will propose strategies for educators, policymakers, and institutions to address the identified challenges, ensuring that ICT tools are utilized effectively to improve learning outcomes in the physical sciences.

By addressing these objectives, the chapter seeks to contribute to the growing body of knowledge on ICT integration in science education, offering practical insights for educators, policymakers, and stakeholders working to enhance the quality of physical sciences education through technology.

6. STATEMENT OF PURPOSE AND AIMS

The primary purpose of this chapter is to explore the transformative potential of Information and Communication Technology (ICT) tools in enhancing the teaching and learning experience within the physical sciences domain. Given the ever-evolving nature of educational technology, this chapter seeks to examine how ICT tools can bridge the gap between theoretical knowledge and practical application in physical sciences disciplines such as physics, chemistry, astronomy, and earth sciences. By leveraging ICT, educators can engage students in dynamic learning experiences that encourage deeper conceptual understanding, critical thinking, and hands-on experimentation. This chapter will analyze the diverse ICT tools available, assess their effectiveness, and highlight how they can be integrated into physical sciences curricula to enhance student engagement, understanding, and achievement.

The chapter aims to achieve several key objectives:

1. Exploring the Role of ICT in Physical Sciences Education

This chapter will investigate the ways in which ICT tools are currently being used to support teaching and learning in physical sciences, with a particular focus on how these tools help students visualize abstract scientific concepts and engage in inquiry-based learning. By reviewing existing research, the chapter will provide a comprehensive understanding of the role that digital technologies can play in transforming physical sciences education.

2. Evaluating the Impact of ICT on Student Engagement and Learning Outcomes

A key aim of this chapter is to evaluate how ICT tools affect student engagement and academic achievement in physical sciences. Through a review of empirical studies, the chapter will examine the impact of ICT on students' understanding of scientific principles, their ability to apply knowledge in practical scenarios, and their overall academic performance. The findings will provide insights into the effectiveness of ICT tools in fostering meaningful learning experiences.

3. Identifying Best Practices for Integrating ICT into Physical Sciences Instruction

The chapter will identify and discuss best practices for integrating ICT tools into physical sciences teaching. Drawing from a range of successful case studies, the chapter will provide practical recommendations for educators on how to incorporate various ICT tools—such as simulations, virtual laboratories, data visualization software, and collaborative online platforms—into their teaching strategies. It will also highlight how these tools can support diverse learning styles and promote personalized learning pathways for students.

4. Addressing the Challenges of ICT Integration in Physical Sciences

Despite the promising potential of ICT, there are several challenges associated with its integration in the classroom, particularly in subjects like physical sciences. This chapter will explore the barriers that educators and institutions face, such as limited access to technology, inadequate infrastructure, lack of digital literacy, and issues of digital equity. By identifying these challenges, the chapter will provide recommendations for overcoming these obstacles to ensure that ICT integration is effective, equitable, and accessible to all students.

5. Examining Emerging Technologies in Physical Sciences Education

The chapter will also address the emerging technologies that are poised to revolutionize physical sciences education. From augmented reality (AR) and virtual reality (VR) to

artificial intelligence (AI) and machine learning, these tools offer new opportunities for creating immersive and interactive learning experiences. The chapter will explore how these technologies are currently being utilized in physical sciences education and discuss their future potential for enhancing student engagement and learning outcomes.

6. Providing Insights for Policy and Practice

Finally, the chapter will provide valuable insights for policymakers, educational leaders, and curriculum designers on how to support the integration of ICT in physical sciences education. By analyzing the existing literature and research, the chapter will outline the key factors that need to be considered for effective policy development and curriculum design that supports the widespread use of ICT tools in science classrooms.

By addressing these aims, this chapter seeks to provide a comprehensive framework for understanding how ICT tools can be effectively leveraged in physical sciences education. It will not only highlight the benefits and opportunities associated with these tools but also offer practical solutions for overcoming the challenges that educators face in integrating technology into their teaching practices. Ultimately, the chapter aims to contribute to the broader conversation on how to enhance physical sciences education through innovative, technology-driven approaches that can prepare students for the demands of the 21st-century world.

7. RESEARCH DESIGN AND METHODOLOGY

7.1. Research Design

This study utilized a mixed-methods research design to investigate the utilization and impact of Information and Communication Technology (ICT) tools in the teaching and learning of physical sciences. The choice of a mixed-methods approach enabled the researchers to combine both qualitative and quantitative data to offer a comprehensive view of pedagogical practices, challenges, and student outcomes related to ICT integration (Archibald et al., 2015). By triangulating findings from multiple data sources, the study aimed to generate nuanced insights into how ICT tools influence teaching effectiveness, student engagement, and academic achievement in physical sciences.

7.2. Sampling Strategy

A purposeful sampling strategy was employed to select participants who were directly involved with ICT-enhanced teaching and learning in physical sciences. Participants included physical sciences educators experienced in integrating ICT into their instructional practices, students who had engaged with ICT tools in the classroom, and relevant stakeholders involved in promoting or supporting ICT integration in educational settings. This targeted sampling approach ensured that the data collected would reflect a rich understanding of the pedagogical and experiential dimensions of ICT use in physical sciences education.

7.3. Data Collection Methods

Three primary data collection methods were utilized to gather both qualitative and quantitative data: semi-structured interviews, classroom observations, and surveys.

Semi-Structured Interviews: In-depth interviews were conducted with physical sciences educators to explore their experiences and perceptions regarding the integration of ICT tools. These interviews focused on the instructional strategies employed, the perceived impact on student learning, and the challenges encountered during ICT-enhanced lessons. Interviews with students were also conducted to capture their perspectives on the

effectiveness and accessibility of ICT tools in fostering their understanding of complex physical science concepts.

Classroom Observations: To complement the interview data, observations were carried out in physical sciences classrooms where ICT tools were integrated into lessons. These observations aimed to document real-time teaching practices, student interactions, and the use of ICT tools. An observation protocol was designed to record qualitative data on instructional approaches, student engagement, and the effectiveness of ICT-enhanced learning activities. The observations provided contextualized insights into how ICT tools were being applied in practice.

Surveys: Quantitative data was collected through surveys administered to both physical sciences educators and students. The surveys aimed to assess the frequency of ICT tool usage, the perceived benefits and challenges of using such tools, and the outcomes associated with ICT integration. Educators were asked to report on the types of ICT tools they used, the extent to which they believed these tools enhanced learning, and any barriers they faced. Students provided feedback on their experiences with ICT-enhanced lessons, including the tools' role in helping them understand challenging scientific concepts.

7.4. Data Analysis

The analysis of the data in this study followed both qualitative and quantitative approaches, reflecting the mixed-methods research design used to investigate the role of ICT tools in physical sciences education. These complementary analyses provided a holistic understanding of the pedagogical practices, challenges, and outcomes associated with ICT integration.

7.4.1. Qualitative Analysis

The qualitative data gathered from semi-structured interviews and classroom observations were analyzed using thematic analysis. This involved a systematic process of coding and categorizing the data to identify recurring patterns and key themes related to ICT use in teaching physical sciences. The themes that emerged focused on pedagogical practices, technological challenges, and student outcomes. For instance, codes related to "enhanced student engagement," "visualization of complex concepts," and "limited access to technology" provided insights into both the benefits and barriers of ICT integration. These themes were then interpreted in relation to the broader research questions to offer an in-depth understanding of how ICT tools influence teaching and learning experiences.

7.4.2. Quantitative Analysis

Descriptive statistical analysis was applied to the survey data to examine patterns and trends concerning the frequency and impact of ICT tools in physical sciences education. The analysis focused on the distribution of responses regarding the perceived benefits of ICT tools, the challenges faced by educators and students, and the overall effectiveness of these tools in enhancing student comprehension and academic performance. Basic statistical measures such as means, frequencies, and percentages were used to summarize the data and present an overarching picture of ICT usage in the surveyed classrooms.

7.4.3. Triangulation

To enhance the validity and reliability of the study, data triangulation was employed. This involved cross-verifying findings from multiple data sources, including interviews, classroom observations, and survey responses. For instance, themes identified in the interviews and observations were corroborated by survey trends, providing a more robust and

comprehensive understanding of the effectiveness of ICT tools in physical sciences education. By integrating different perspectives, the study minimized potential biases and strengthened the credibility of the conclusions drawn.

7.4.4. Trustworthiness

Several strategies were implemented to ensure the trustworthiness of the qualitative findings. Member checking was conducted by sharing preliminary results with participants to confirm the accuracy of the interpretations. Peer debriefing involved discussions with colleagues to refine the analysis and ensure the consistency of the coding process. Additionally, prolonged engagement with the data allowed for a deeper immersion in the content, contributing to the credibility, dependability, and transferability of the findings.

8. FINDINGS

The study revealed several key insights regarding the utilization and impact of ICT tools in physical sciences education:

8.1. Extent of ICT Integration

ICT tools were found to be extensively integrated into teaching practices in physical sciences classrooms. Educators utilized a wide range of digital resources, such as interactive simulations, virtual laboratories, multimedia presentations, and online collaboration platforms. These tools were employed to facilitate instruction, provide visual and hands-on learning experiences, and support student-centered learning environments.

8.2. Pedagogical Strategies

A variety of pedagogical strategies were identified in the context of ICT integration. Educators used approaches such as inquiry-based learning, flipped classroom models, and blended learning environments. These methods were tailored to fit the specific instructional goals and the diverse learning needs of students. For example, inquiry-based learning allowed students to explore scientific concepts through guided experimentation, while flipped classrooms provided opportunities for students to engage with content both inside and outside the classroom.

8.3. Student Engagement

The study found that ICT-enhanced instruction significantly increased student engagement and participation in physical sciences education. Tools like interactive simulations, multimedia presentations, and virtual labs encouraged active exploration and hands-on learning. These resources captured students' attention, making abstract scientific concepts more relatable and stimulating curiosity about real-world applications.

8.4. Conceptual Understanding

ICT tools played a critical role in fostering deeper conceptual understanding of physical sciences topics. Visualization tools, such as interactive simulations, helped students better grasp abstract concepts, while data analysis software allowed them to experiment with real-world data and apply theoretical knowledge. Virtual labs enabled students to conduct experiments that might be difficult or impossible to perform in a traditional classroom setting, further reinforcing their understanding of key scientific principles.

8.5. Technological Challenges

Despite the benefits, educators faced several technological challenges when integrating ICT into their teaching practices. Limited access to technology, software glitches, hardware issues, and insufficient technical support were common barriers. Additionally, some educators highlighted the need for continuous professional development in ICT skills to effectively leverage these tools for pedagogical purposes.

8.6. Teacher Professional Development

The study emphasized the importance of ongoing teacher professional development to support effective ICT integration in physical sciences education. Workshops, mentoring programs, and collaborative learning communities were identified as essential for enhancing educators' technological proficiency and pedagogical practices. This professional growth was viewed as critical to optimizing the use of ICT tools and ensuring that students benefit fully from technology-enhanced learning experiences.

The findings underscore the transformative potential of ICT tools in physical sciences education. While the integration of ICT significantly enhances student engagement, conceptual understanding, and inquiry-based learning, addressing technological challenges and investing in teacher professional development are key to maximizing its effectiveness. With proper support, ICT tools can revolutionize teaching and learning in physical sciences, fostering a more interactive, engaging, and effective educational environment.

9. DISCUSSION

The findings of this study shed light on the pivotal role that ICT tools play in transforming physical sciences education, offering valuable insights into both the benefits and challenges associated with their integration. In this discussion, we connect the key findings to existing literature, offering a contextual understanding of the impact of ICT tools on teaching and learning in the physical sciences.

The widespread adoption of ICT tools, such as interactive simulations, virtual laboratories, multimedia presentations, and online collaboration platforms, reflects a significant shift in how educators approach teaching in the physical sciences. These findings align with Haleem et al. (2022), who highlighted the transformative potential of digital technologies in fostering active learning environments. The adoption of such diverse tools is indicative of educators' growing recognition of technology's potential to enhance instruction and provide immersive learning experiences. These technologies offer a means to present scientific concepts in ways that were previously unimaginable, moving beyond traditional methods to support more dynamic and interactive learning environments (Alam & Mohanty, 2023).

The study's findings regarding the pedagogical strategies employed by educators mirror the trends seen in current educational reforms. Educators' use of inquiry-based learning, flipped classroom models, and blended learning environments echoes the calls for more student-centered teaching approaches (Bernacki, Greene & Lobczowski, 2021). Inquiry-based learning was noted for allowing students to explore scientific concepts through guided experimentation. This aligns with constructivist theories, which emphasize the importance of learners actively constructing knowledge through exploration and hands-on experiences. These pedagogical strategies underscore the adaptability of ICT tools to meet the diverse needs of learners, offering personalized, flexible learning experiences.

The increase in student engagement observed in this study supports the growing body of literature that attests to the positive impact of ICT tools on student motivation and involvement in learning (Baako & Abroampa, 2023). Tools like interactive simulations and virtual labs have been found to foster an environment where students actively engage with content, experiment with scientific concepts, and explore real-world applications in a risk-free environment. This heightened engagement is not only a surface-level enhancement; it leads to deeper, more meaningful interactions with content, allowing students to better understand complex scientific theories. By offering hands-on, immersive experiences, ICT tools help bridge the gap between abstract concepts and practical application, thus enhancing students' overall learning experience (Siadat, Gašević & Hatala, 2016).

The critical role that ICT tools play in deepening students' conceptual understanding of physical sciences topics aligns with findings from Siadat, Gašević, and Hatala (2016), who emphasized the value of visualization tools in helping students grasp abstract concepts. Virtual labs, interactive simulations, and data analysis software serve as scaffolding tools, allowing students to experiment with real-world data, conduct virtual experiments, and visualize complex phenomena. These resources help bridge the gap between theoretical knowledge and practical application, making abstract concepts more accessible and understandable. The ability to engage in virtual experiments also supports the development of problem-solving and critical thinking skills, which are essential components of science education (Hinojosa et al., 2024).

Despite the significant benefits of ICT integration, the study also highlights several barriers that impede its effectiveness. These challenges are consistent with those reported in the literature, including limited access to technology, technical difficulties, and insufficient infrastructure (Wang et al., 2024). In under-resourced contexts, these barriers can severely limit the extent to which ICT can be used to enhance education. To maximize the benefits of ICT tools in physical sciences education, there needs to be a concerted effort to address these challenges by investing in infrastructure, providing technical support, and ensuring equitable access to technology for all learners (Maree, 2022).

The findings emphasize the critical need for ongoing professional development to support teachers in effectively integrating ICT tools into their teaching practices. This is in line with the literature, which consistently stresses that professional development is crucial for equipping educators with the necessary skills and knowledge to use technology effectively (Bernacki et al., 2021). Without adequate training and support, teachers may struggle to harness the full potential of ICT tools, hindering the effectiveness of technology-enhanced learning. Continuous professional development through workshops, mentoring programs, and collaborative learning communities is essential to ensure that educators remain up to date with technological advancements and best practices for integrating technology into their pedagogical approaches (Haleem et al., 2022).

The discussion of the study's findings underscores the transformative potential of ICT tools in physical sciences education. By significantly enhancing student engagement, conceptual understanding, and the overall learning experience, ICT tools have the capacity to revolutionize science teaching and learning. However, to fully realize their potential, it is imperative to address the technological challenges faced by educators and to invest in comprehensive professional development programs. By doing so, we can ensure that ICT tools are effectively integrated into the curriculum and that educators are adequately prepared to utilize these tools to their fullest potential. This chapter contributes to the growing body of research on ICT in education by providing a nuanced understanding of its impact on physical sciences education, offering practical insights for educators, policymakers, and stakeholders to consider in the pursuit of more effective and inclusive science education.

10. IMPLICATIONS FOR PEDAGOGIC INNOVATION

The integration of Information and Communication Technology (ICT) tools in physical sciences education holds significant implications for pedagogic innovation. As educational technology continues to evolve, its impact on teaching and learning offers valuable opportunities for enhancing pedagogical practices and improving educational outcomes. This chapter's findings underscore several key implications for pedagogic innovation in the realm of physical sciences education:

The widespread use of ICT tools necessitates a rethinking of traditional teaching methods. Educators are increasingly adopting innovative pedagogical approaches such as inquiry-based learning, flipped classrooms, and blended learning environments. These methods leverage the capabilities of ICT tools to create interactive and student-centered learning experiences. For instance, inquiry-based learning approaches supported by interactive simulations can foster deeper exploration and understanding of scientific concepts, while flipped classrooms enable more dynamic and engaged in-class discussions (Ehtinen & Viiri, 2017). This shift in teaching methods promotes a more active and participatory learning environment, aligning with contemporary educational theories.

ICT tools have the potential to significantly enhance student engagement and motivation. The use of interactive simulations, multimedia presentations, and virtual laboratories captivates students' interest and provides immersive learning experiences (Kanwal & Alvarez, 2021). These tools facilitate hands-on exploration and experimentation, making abstract concepts more accessible and engaging. By incorporating technology into the curriculum, educators can create learning experiences that resonate with students, increase their motivation, and encourage active participation in the learning process.

One of the major advantages of ICT tools is their ability to support differentiated instruction. Technology enables educators to tailor instructional materials and activities to meet the diverse needs of students. For example, multimedia presentations and interactive simulations can be customized to address different learning styles and paces (De Back, Tinga & Louwerse, 2021). This adaptability allows educators to provide personalized learning experiences that cater to individual strengths and challenges, promoting more effective learning outcomes for all students.

ICT tools enable students to connect theoretical knowledge with real-world applications. Visualization tools, data analysis software, and virtual laboratories provide opportunities for students to conduct experiments, analyze data, and apply scientific concepts to practical scenarios (Elmoazen et al., 2023). This connection between theory and practice enhances students' conceptual understanding and prepares them for real-world problem-solving. By integrating technology that simulates real-world conditions, educators can bridge the gap between classroom learning and practical applications in the field.

While the integration of ICT tools offers numerous benefits, it also presents challenges that need to be addressed. Limited access to technology resources, technical issues, and the need for ongoing professional development are significant barriers to effective ICT integration (Hébert, Jenson & Terzopoulos, 2021). Addressing these challenges requires a concerted effort to improve technology infrastructure, provide adequate technical support, and invest in professional development programs. By tackling these issues, educators can better leverage ICT tools to enhance their teaching practices and improve student outcomes.

To maximize the potential of ICT tools in physical sciences education, continuous professional development for educators is essential. Training workshops, mentoring programs, and collaborative learning communities can enhance educators' technological proficiency and pedagogical practices (Geletu, 2023). Investing in professional development

helps educators stay abreast of technological advancements, refine their instructional strategies, and effectively integrate ICT tools into their teaching.

Overall, the integration of ICT tools in physical sciences education has profound implications for pedagogic innovation. By embracing new teaching methods, enhancing student engagement, supporting differentiated instruction, facilitating real-world connections, addressing technological challenges, and promoting continuous professional development, educators can transform their pedagogical practices and create more effective and engaging learning environments. The ongoing exploration and adoption of ICT tools will continue to drive innovation in education, ultimately contributing to improved teaching and learning outcomes in the field of physical sciences.

11. FUTURE RESEARCH DIRECTIONS

The integration of Information and Communication Technology (ICT) tools in physical sciences education presents a dynamic and evolving landscape. As educational technology continues to advance, future research should focus on several key areas to further enhance our understanding and application of ICT in this domain.

Longitudinal Impact Studies: To comprehensively assess the long-term effects of ICT tools on physical sciences education, future research should employ longitudinal studies. These studies would track the progress of students and educators over extended periods, evaluating how sustained use of ICT tools influences learning outcomes, retention of scientific concepts, and overall academic performance.

Comparative Effectiveness of ICT Tools: Investigating the comparative effectiveness of various ICT tools can provide insights into which technologies offer the greatest benefits. Research could compare the impact of different tools—such as interactive simulations, virtual laboratories, and multimedia presentations—on student engagement, conceptual understanding, and problem-solving skills. This approach will help identify the most effective tools for specific educational goals.

Pedagogical Models and ICT Integration: Further research should explore how different pedagogical models—such as inquiry-based learning, flipped classrooms, and blended learning—interact with ICT tools. Understanding how these models leverage technology to address specific instructional needs can inform best practices for integrating ICT in physical sciences education, ensuring that technology enhances pedagogical approaches effectively.

Technological Challenges and Solutions: Addressing the technological challenges identified in this study is critical for effective ICT integration. Future research should focus on developing and evaluating solutions for common issues such as limited access to resources, technical problems, and inadequate support structures. Investigating strategies to improve technology infrastructure and support can help overcome barriers and enhance the implementation of ICT tools.

Professional Development and Support Programs: The effectiveness of various professional development programs for educators in ICT integration warrants further investigation. Research should evaluate the impact of training workshops, mentoring programs, and collaborative learning communities on educators' technological proficiency and pedagogical practices. This will help identify effective methods for supporting teachers in their use of ICT tools.

Student-Centered Research: Exploring students' perspectives on ICT tools is essential for understanding how technology impacts their learning experiences. Future research should focus on students' attitudes, engagement levels, and learning preferences related to different

ICT tools. This research will help tailor ICT integration strategies to better meet students' needs and enhance their learning experiences.

Emerging Technologies in Education: With the rapid evolution of technology, research should also explore the integration of emerging technologies such as artificial intelligence, virtual reality, and augmented reality in physical sciences education. Investigating how these advanced technologies can be utilized to create innovative and immersive learning experiences will be crucial for staying at the forefront of educational technology.

By addressing these future research directions, educators, researchers, and policymakers can continue to refine and enhance the integration of ICT tools in physical sciences education. This ongoing research will contribute to more effective teaching practices, improved student outcomes, and a richer, more engaging learning environment.

12. UNIQUE CONTRIBUTIONS OF THE CHAPTER

This chapter makes several significant contributions to the existing body of work on Information and Communication Technology (ICT) integration in physical sciences education, offering novel insights and addressing gaps in the current literature. By providing a comprehensive and nuanced analysis of ICT tools in the physical sciences context, it not only highlights opportunities for enhancing learning but also tackles the inherent challenges faced by educators. The chapter's unique contributions are outlined below:

Comprehensive Exploration of ICT Tools Across Physical Science Disciplines

Unlike many existing studies that focus on ICT tools in isolated science disciplines (e.g., physics or chemistry), this chapter provides a broad exploration of how ICT tools can be used across the spectrum of physical sciences, including physics, chemistry, earth sciences, and astronomy. By considering the diverse needs and pedagogical approaches within each discipline, the chapter offers a more holistic understanding of how ICT can address the unique challenges and learning objectives of these fields.

Pedagogical Framework for ICT Integration

The chapter contributes to the theoretical development of ICT integration by proposing a pedagogical framework that aligns with inquiry-based learning, problem-solving, and experiential learning approaches. The integration of these pedagogical strategies with ICT tools offers a tailored approach to teaching and learning in the physical sciences, moving beyond surface-level applications of technology to foster deeper student engagement and comprehension. This framework serves as a practical guide for educators seeking to effectively combine digital tools with sound pedagogical principles.

Insights into the Impact of ICT on Conceptual Understanding and Student Engagement

A key contribution of this chapter is its focus on the impact of ICT tools on students' conceptual understanding and engagement with complex scientific concepts. By providing evidence from case studies and classroom examples, it demonstrates how tools such as simulations, virtual laboratories, and interactive multimedia can transform abstract theories into tangible experiences, making learning more accessible and engaging. This contribution bridges the gap between the theoretical benefits of ICT and its real-world impact on students' learning outcomes.

Identification and Analysis of Barriers to ICT Integration in Physical Sciences

While many studies acknowledge the barriers to ICT adoption, this chapter provides a detailed examination of the specific challenges within the context of physical sciences education. It identifies key obstacles such as digital equity, the digital divide, infrastructure limitations, and the lack of professional development for teachers in using ICT tools effectively. By focusing on these barriers, the chapter offers a targeted perspective that is

often overlooked in broader discussions about ICT in education, thus providing a clearer understanding of the specific constraints in the physical sciences domain.

Global and Local Perspectives on ICT Integration

This chapter stands out for its incorporation of both global trends and local challenges in ICT integration. While drawing on international best practices, it also considers the unique challenges faced by educators in under-resourced contexts, particularly in developing regions or underserved schools. This balanced approach ensures that the recommendations and strategies offered are applicable to a wide range of educational environments, from well-resourced institutions to those facing technological and infrastructural challenges.

Practical Recommendations for Educators and Policymakers

Beyond theoretical analysis, the chapter provides actionable recommendations for educators, school administrators, and policymakers on how to optimize the use of ICT tools in physical sciences classrooms. These recommendations are based on empirical research and case studies and focus on overcoming barriers such as limited access to technology, insufficient teacher training, and the need for targeted educational policies that support ICT integration. By offering practical solutions, the chapter ensures that its insights can be directly applied to improve teaching and learning in real-world educational settings.

Exploration of Future Research Directions

The chapter also makes an important contribution by highlighting key areas for future research in ICT integration in the physical sciences. It suggests exploring the long-term effects of ICT tools on student learning outcomes, evaluating the impact of emerging technologies such as artificial intelligence and virtual reality in science education, and investigating how ICT can support diverse learning needs in science classrooms. These research directions offer valuable pathways for expanding the understanding of ICT's role in science education.

In summary, this chapter provides a comprehensive, evidence-based exploration of the integration of ICT tools in physical sciences education, filling critical gaps in the existing literature. Its unique contributions—ranging from a pedagogical framework for ICT use, to a detailed analysis of barriers, to actionable recommendations for educators and policymakers—ensure that it adds significant value to the field. By offering practical insights and identifying future research opportunities, the chapter aims to foster a more effective and inclusive approach to teaching and learning in the physical sciences through ICT integration.

13. CONCLUSION

This study offers significant insights into the integration and impact of Information and Communication Technology (ICT) tools in physical sciences education. The findings highlight the profound ways in which ICT tools can transform teaching practices, enrich student learning experiences, and foster a deeper understanding of scientific concepts. The widespread adoption of ICT tools by educators in physical sciences underscores a growing recognition of technology's potential to enhance instruction and actively engage students in their learning journey.

The study reveals that educators effectively utilize a range of digital resources, including interactive simulations, virtual laboratories, multimedia presentations, and online collaboration platforms. These tools have been shown to increase student engagement and participation by offering dynamic and immersive learning experiences. By incorporating pedagogical strategies such as inquiry-based learning, flipped classroom models, and blended learning environments, educators can adapt their teaching methods to better align with technological advancements and meet diverse learning needs.

Moreover, ICT tools contribute significantly to students' conceptual understanding and retention of physical sciences concepts. They enable students to visualize abstract ideas, analyze data, and apply theoretical knowledge in practical contexts. This capability to facilitate hands-on exploration and experimentation not only enhances comprehension but also supports the development of critical thinking and problem-solving skills.

Despite these advantages, the study also highlights several challenges associated with ICT integration. Issues such as limited access to technology resources, technical difficulties, and the need for ongoing professional development can hinder the effective implementation of ICT-enhanced instruction. Addressing these challenges is essential for maximizing the benefits of technology in education. Investing in professional development opportunities—such as training workshops, mentoring programs, and collaborative learning communities—can equip educators with the skills and knowledge necessary to leverage ICT tools effectively.

In conclusion, this study underscores the importance of strategically leveraging ICT tools to enhance teaching and learning in physical sciences. By overcoming technological barriers and committing to continuous professional development, educators can fully harness the transformative potential of technology. Such efforts will enable the creation of dynamic, engaging, and effective learning environments, preparing students for success in an increasingly digital world. The insights gained from this research contribute to a broader understanding of how technology can be used to innovate and improve educational practices, ultimately fostering a richer and more interactive learning experience for students.

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KEY TERMS & DEFINITIONS

Information and Communication Technology (ICT): The use of digital tools, systems, and technologies to facilitate the collection, storage, retrieval, processing, and dissemination of information in education and other fields.

Blended Learning: An instructional approach that combines traditional face-to-face teaching with online and digital learning methods, leveraging ICT tools to enhance the learning experience.

Interactive Simulations: Digital tools that replicate real-world processes or phenomena, allowing learners to manipulate variables and observe outcomes, commonly used in Physical Sciences for experiments and concept visualization.

Virtual Laboratories: Online platforms or software that enable students to perform science experiments in a simulated environment, providing a cost-effective and safe alternative to physical labs.

Gamification: The incorporation of game elements, such as points, badges, and leaderboards, into educational activities to motivate and engage learners.

Augmented Reality (AR): Technology that overlays digital content onto the real world, enabling an interactive and immersive learning experience, especially for visualizing abstract scientific concepts.

Digital Literacy: The ability to effectively and critically navigate, evaluate, and create information using a range of digital technologies.

Learning Management System (LMS): A software application for managing educational courses, training programs, or learning content, providing tools for delivering materials, tracking progress, and assessing performance.

Coding and Computational Thinking: The process of using logical reasoning and programming to solve problems or simulate scientific phenomena, often integrated with Physical Sciences curricula.

Digital Pedagogy: The practice of teaching using digital tools and platforms, emphasizing the intentional and effective integration of technology into instruction.

STEM Education: An interdisciplinary approach to learning that integrates Science, Technology, Engineering, and Mathematics, often supported by ICT tools to foster problem-solving and critical thinking skills.

Artificial Intelligence (AI) in Education: The application of AI technologies, such as adaptive learning systems and virtual assistants, to personalize and optimize the learning experience.

Inquiry-Based Learning: A student-centered approach where learners use ICT tools to explore scientific questions, conduct research, and construct their own understanding.

ICT Integration: The strategic incorporation of digital tools and resources into the curriculum to enhance teaching, learning, and assessment.

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Section 2

Projects and Trends

Chapter # 19

BARRIERS TO FLIPPED CLASSROOMS IN SOUTH AFRICAN UNIVERSITIES: CONTEXT AND CONTENT CHALLENGES

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ABSTRACT

A significant shift in pedagogical methods is the adoption of the Flipped classroom approach. This method challenges direct instruction as the most efficient use of class time. Instead, it encourages students to engage with new material before coming to class, reserving class time for activities that foster higher-order thinking and activity. While this strategy addresses limited classroom time, it often overlooks the complexity and cognitive demand of module content, as well as the socio-cultural contexts within South Africa's diverse higher education landscape. This qualitative research investigates the challenges associated with implementing the Flipped classroom model within South African Higher Education. Using a case study approach, data was collected through questionnaires with South African University students to assess the influence of their community backgrounds. Additionally, semi-structured interviews with a lecturer were conducted to evaluate cognitive demands and support needed for this instructional approach. The findings reveal that the community contexts, combined with the cognitive challenges posed by module content, significantly impede the successful implementation of the Flipped classroom model. The study recommends that South African universities prioritize community engagement initiatives that foster supportive learning environments and invest in university residences equipped with the necessary infrastructure and academic support.

Keywords: flipped classrooms, community, context, content.

1. INTRODUCTION

The higher education academic experience is an inherently interactive process, shaped by various factors that contribute to the success of students. Among these, engagement and student motivation are considered pivotal to academic achievement (Barkley & Major, 2020). As a result, the academic community has sought pedagogical strategies to sustain student motivation and involvement. To this end, scholars as early as the late 19th century advocated for technology integration to enhance student participation and academic success (see Clark, 1983; Chickering & Ehrmann, 1996, Bates, 2000). Their argument was that students born into an increasingly digital age required engaging and dynamic digital education to thrive in the modern world. Consequently, the rapid advancement in technology necessitated a shift in pedagogical approaches to match these changes. Key approaches include cognitive load theory, connectivism, multimodal learning theory, and most notably, the Flipped Classroom model. This method distinguishes itself by seamlessly blending traditional teaching with technology-driven tools (Naidoo, 2020) and reshaping the conventional learning environment. It advocates for a reallocation of in-class and out-of-class activities, shifting the responsibility for learning from the instructor to the student (Kashada & Li, 2017).

The South African higher education sector is also embracing the shift towards pedagogical approaches suited for technology-based learning. This is in response to recent statistics that revealed a national throughput rate of only 18.9% for 3-year degrees in 2015 by the Department of Higher Education in 2019. As a result, it was recommended that technology be explored as a strategy to improve university throughput rates across the country. In response to this recommendation, South African academics have turned to the Flipped Classroom approach as an effective technology-driven pedagogy (Cilliers & Pylman, 2022). This pedagogy gained further prominence during the COVID-19 pandemic, both in South Africa and globally. Research has shown that students who followed a flipped methodology during the pandemic improved their digital skills and increased their motivation (Cuevas Monzonis, N., Gabarda Méndez, V., Cívico Ari, A., & Colomo Magaña, 2020). In Spain, Collado-Valero et al. (2021) observed a significant rise in the use of various online digital resources within the FC approach in higher education.

However, caution is necessary when implementing this approach within the complex South African context, both inside and outside the classroom. For a developing country like South Africa, the implementation is hindered by factors such as limited internet access, inadequate ICT infrastructure, insufficient government support, lack of computer ownership, professional development gaps, and a slow pace of change (Kashada & Li, 2017). Additionally, content creation and delivery face challenges such as language barriers (Mwaniki, 2012), varying assessment standards, and a lack of parental support. The practicality of the Flipped Classroom approach in South African higher education is thus constrained by numerous structural and socio-economic issues, both within the university and the surrounding community. In this regard, universities should redirect their community development efforts inward, aiming to "flip" local communities so that students can fully benefit from the Flipped Classroom model, even beyond the pandemic. The objective of this study is to explore how the South African context and module content serve as barriers to implementing the Flipped Classroom approach in a local university.

2. HISTORICAL CONTEXT OF SOUTH AFRICAN UNIVERSITIES

Any discourse on South Africa is inevitably intertwined with its difficult history. This historical context is crucial, as it provides insight into many of the challenges the country continues to face today. In relation to South African universities, the foundation of the higher education system dates back to 1873, with the establishment of the first degree-granting institution, the University of the Cape of Good Hope (Boucher, 1975). This institution was created through an Anglo-British initiative, under the University Incorporation Act 16 of 1873, and was exclusively available to English-speaking white European settlers. The primary objective was to advance education and research within the colonies beyond secondary education (Boucher, 1975). It also served as a training ground for colonial administrators tasked with implementing colonial policies.

After colonization, the apartheid government shifted its focus to Afrikaner universities located in the former Transvaal and Orange Free State. Although these institutions were designated exclusively for white South Africans under the Separate Amenities Act of 1953, the state's growing development highlighted the need for a more skilled workforce. It wasn't until the Extension of Universities Act in 1959 that any attention was given to institutions for non-white South Africans (Mdepa & Tshiwula, 2012). This delay illustrates that historically black universities only began receiving state recognition and support decades after their white counterparts. During apartheid's 45-year rule, which extended the legacy of 350 years of colonialism, the government established a racially segregated higher education system,

consisting of 36 universities, 15 Technikons, and around 140 specialized vocational colleges (focusing on nursing, education, and agriculture). These institutions were segregated by race in terms of both admissions and tuition (Mdepa & Tshiwula, 2012).

The gruesome history communities in South Africa is similar to that of the university. Evidence of this irreparable history lies in the creation of the Group Areas Act of 1950. This Act mandated separate living areas for whites and non-whites in South Africa. The separation and spatial planning of living allocation reserved suburban and urban areas for white occupation and township and rural locations for non-white occupation (Philip, 2014). Findley and Ogbu (2011) detail the impact of this segregation and the lack of attention and development allocated to South African townships during the Apartheid administrations. “Transport was limited to state-owned buses and trains, and the scarcity of commercial development forced many township residents to shop in faraway white-owned centers, or in licensed white-owned or Indian-owned shops dispersed around the townships. Leisure activities were also strictly regulated: the only legal beer halls were in government buildings, and dirt lots served as soccer fields. Schools were poorly maintained barrack-like structures with barred windows and secondhand desks. There were no cultural facilities, though churches did provide places of community and belonging” (Findley & Ogbu, 2011).

Townships echoed the tension between the need to keep non-white South Africans close enough to provide a secure source of cheap labour, but far enough to maintain social distancing and separate development. The long-lasting effects of this are the current socio-economic issues prevalent in South African townships and rural areas. Amongst the many included is the lack of infrastructure (Pernegger & Godehart, 2017), unemployment and crime (Barrar, 2010), teenage pregnancy (Mkhwanazi, 2010) as well as a general decay in the social and moral fibre of communal living. Therefore, South African universities face a dual challenge: they are burdened by centuries of financial and resource inequalities between historically black and white institutions, while historically black universities remain located in townships still deeply affected by the socio-economic disparities stemming from the country’s painful history. The application of a resource-demanding and technological based pedagogy such as the flipped classroom approach requires caution in such a context. Given this historical backdrop, the study explores the challenges involved in implementing the flipped classroom model in South African universities, where most students hail from these communities.

3. A FLIPPED CLASSROOM APPROACH: THEORETICAL UNDERPINNING

The flipped classroom approach originated in the late 1990s as a pedagogical tool, initially designed by teachers to offer supplementary content for students who missed class. It later evolved within Higher Education institutions across Northern Europe, with the goal of maximizing lecture contact time. Early advocates, Bergmann and Sams (2012) observed that students who accessed course material at home could utilize class time for more interactive and meaningful activities, such as experiments and group discussions (Cilliers & Pylman, 2022). The core idea underpinning this theoretical framework is that flipping the classroom enables learners to actively gather information outside of designated class time by engaging with content through reading, watching, or listening (Bergmann & Sams, 2012). They further assert that this approach fosters active learning and is more student-centered than the traditional lecture-based model. In this approach, students construct knowledge as they prepare for class (Sohrabi & Iraj, 2016). This knowledge is then tested when the lecturer

creates a classroom environment where students can apply and challenge their newly acquired knowledge in real-life contexts. As a result, the teacher can devote more time to addressing both the learning and emotional needs of students (Goodwin & Miller, 2013). This ontological perspective aligns closely with constructivist learning theories, where students actively construct meaning and understanding through experiences and interactions (Tanner & Scott, 2015). Bergmann and Sams (2012) outline the following four pillars of the Flipped Classroom approach:

Flexible environment

Unlike conventional classrooms, which are often not encouraging to learning, flipped classrooms encourage students to work collaboratively in highly flexible environments. Students have the autonomy to decide when and where to engage with the material, and lecturers accommodate these choices. Naidoo (2020) supports this view, describing flexible environments as productive and conducive spaces outside the classroom where learners can engage with content in a comfortable and adaptable setting. Additionally, this approach emphasizes that content should be accessible at any time and from any location.

i) A change in the learning culture

This principle advocates that lecturers should help students explore topics more deeply through the use of student-centered pedagogies. Unlike traditional methods, which position the lecturer as the sole holder and dispenser of knowledge, the flipped classroom shifts the focus, empowering students to take ownership of the knowledge creation process. In this approach, there is a clear transition from a teacher-centered to a student-centered model of learning.

ii) Intentional content

This principle emphasizes that lecturers must be deliberate and thoughtful in how content is both created and consumed by students (Naidoo, 2020). The primary goal is to align the content with appropriate instructional delivery methods. Additionally, lecturers need to be adaptable, shifting away from traditional instructional techniques when necessary.

iii) Professional educator

For the flipped classroom approach to be successful, experienced lecturers are best suited, as they need to capitalize on available learning opportunities and carefully monitor students to guide their progress (Kashada & Li, 2017). This study examines these four pillars to explore how contextual factors and content may serve as barriers to the implementation of the flipped classroom model in a South African university.

In assessing the limitations of the theory, it is important to note what the theory is not. According to Ozdamli & Asiksoy (2016, p.100), 'Flipped classroom approach is not synonym with online videos, the important point is the interactive activities done during time when teacher and students are face to face'. They further add that 'it is not using video instead of teacher. It is not working unsystematically of students. It is not students spending all course period in front of a computer. It is not a student studying alone' (Ozdamli & Asiksov, 2016, p. 100). Nonetheless, teachers who use the approached have noted that students may be stubborn at the beginning and may come to class without preparation. This invertedly wastes time as the model depends on learners independently preparing for the class engagement. Teachers also noted the difficulty in finding good quality materials online for the learners to use and understand on their own (Herreid & Schiller, 2013). The most notable of these limitations of the theory is the lack of equipment such as smart phones, tablets or computers and having internet problems (Kordyban & Kinash, 2013). This is particularly important in the case of the South African University as explored by this study, as the implementation of the theory rests heavily on this contextually dynamic.

4. METHODOLOGICAL PROCEDURE

The objective of this study was to investigate how context and content serve as barriers to implementing the flipped classroom model in a South African university. This qualitative research employed a case study design, which Babbie and Mouton (2001) defines as an in-depth analysis of a particular case or bounded system. This method was chosen to facilitate a thorough exploration of both the university's context and the content of a specific module within that institution.

Purposive sampling was utilized to select a university located in a township in Kwa-Zulu Natal, chosen for its unique context relevant to the study. Within this university, one first-year Engineering class was selected based on the assumption that these students' relative inexperience would yield valuable insights into both contextual and content-related barriers. Data was collected using semi-structured questionnaires and one-on-one interviews. The semi-structured questionnaires included both open-ended and close-ended questions, designed to explore students' community contexts and their experiences with the module content. The interview with the Engineering lecturer focused on the module's content and its alignment with the flipped classroom approach. The development of these instruments involved a thorough review of relevant literature and piloting to ensure clarity and relevance. Thematic analysis was used to analyse the data, with themes identified through iterative coding and examination. The analysis focused on themes such as flexible environment, a change in learning culture, intentional content, and professional teachers (Bergmann & Sams, 2007).

Ethical considerations were addressed through obtaining informed consent from all participants, who were fully briefed on the study's purpose, voluntary nature, and their right to withdraw at any time. Confidentiality was maintained by anonymizing data and securely storing all materials. Ethical clearance was granted by the institution and relevant gatekeepers. The study's findings are specific to the selected university and class, and therefore may not be generalizable to other contexts. Potential limitations include the subjective nature of qualitative data, the specific context of the selected university, and the focus on a single class, which may influence the findings and their applicability to broader settings. Additionally, while the study addresses barriers to implementation, it does not explore all potential challenges or practical considerations associated with the flipped classroom approach.

5. RESULTS AND DISCUSSION OF FINDINGS

A total of 72 first-year Engineering students participated in the questionnaire, which sought to examine how their context and the course content influenced the implementation of the flipped classroom approach. The first two key components of this model—flexible environments and professional educator (Bergmann & Sams, 2007)—addressed the implications of context, while the latter two components— a shift in learning culture and intentional content (Bergmann & Sams, 2007)—focused on the implications of content.

i) Contextual barriers to a flipped classroom approach

Flexible environments

For the flipped classroom approach to be successful, the alternative flexible environment must be both conducive and supportive. Many South African universities were constructed during the apartheid era, which did not account for the high enrollment of previously disadvantaged groups. As a result, these institutions often have limited on-campus student housing (Mzileni & Mkhize, 2019). Furthermore, they point out that students frequently endure unhygienic, unsafe, and poorly equipped private accommodations. As shown in Figure 1, 62.5% of the 72 respondents live in off-campus housing. This situation is common across many South African universities due to the legacy of apartheid-era spatial planning (Mzileni & Mkhize, 2019).

*Graph 1.
Student residency during studies.*



Flexible environments should include resource centers to support students using the flipped classroom model. This approach encourages students to complete and engage with course content outside of the classroom, freeing up lecture time for activities such as application, experimentation, and exploration (Berrett, 2012). However, in addition to 62.5% of respondents living off-campus, their residences lack the media centers and resources necessary to facilitate this type of learning. Graph 2 illustrates that nearly 70% of respondents do not have access to media centers near their accommodations. Furthermore, 65% of respondents reported sharing a room with more than one person, making it exceedingly difficult to create a conducive study environment. The lack of individualized space, as depicted in Graph 3, highlights the challenges of implementing the flipped classroom model, as students do not have access to the flexible environments essential for its success.

*Graph 2.
Resident room occupants.*

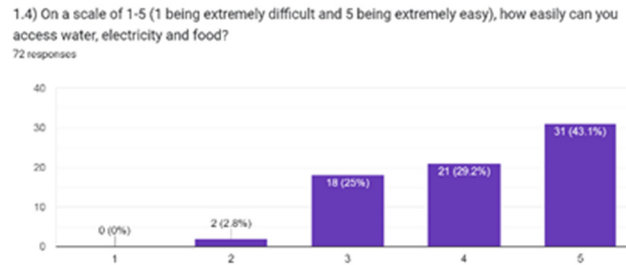


Graph 3.
Access to media centre and resources.



The study found that the context and living environment in which South Africa students predominantly find themselves in makes it difficult to effectively implement a flipped classroom approach. A greater effort is required in establishing communities with media centres and resourced facilities to support South African Students. Far beyond media centres and resource facilities, communities in South Africa still need to deliver basic needs that not only facilitate a flipped approach, but basic education conditions for South African student (Du Plessis & Amoah, 2022). Testament to this is how only 43% of respondent reported not struggling to access of basic service delivery such as water and electricity as shown in table 1.

Table 1.
Access to basic service delivery.



Professional educator

A key principle of the flipped classroom model is that lecturers must be experienced and well-suited to take full advantage of the learning opportunities the methodology offers (Kashada & Li, 2017). To investigate this aspect, the study interviewed the Electrical Engineering lecturer responsible for teaching first-year Engineering students. The lecturer, who holds an MSc in Engineering and has seven years of teaching experience—five of which were in secondary education—stated that they had not undergone any formal training or capacity-building programs related to the flipped classroom model. Alexander and Masoabi (2017) observe that while South African Engineering academics possess strong content knowledge, many struggle to effectively convey this knowledge pedagogically due to a lack of teacher training. In response, the South African Department of Higher Education has been encouraging academics outside the teaching faculty to pursue pedagogical qualifications in addition to their professional credentials. When the flipped classroom approach was

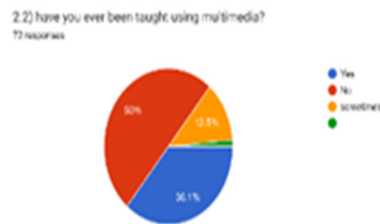
explained to the lecturer, they expressed concerns that their institution might lack the necessary technical support and resources to implement the model effectively.

ii) Content barriers to a flipped classroom approach

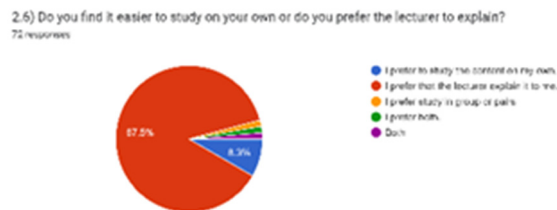
A change in learning culture

A key principle of the flipped classroom model is that lecturers should help students explore topics in greater depth by using tools and pedagogies that are student-centered (Naidoo, 2020). Encouragingly, this study found that more than 50% of respondents had been taught using various multimedia, as shown in Graph 4. This is a positive sign for the future of the flipped classroom model in South Africa, as students are somewhat familiar with the tools utilized in this approach. However, further efforts are needed to familiarize students with student-centered pedagogies, as an overwhelming 87% of respondents indicated a preference for the lecturer to explain the content to them. This tendency is attributed to the fact that first-year students typically come from secondary schools that predominantly rely on teacher-centered methods for content delivery. Sedibe (2011) explains that this is because many under-resourced South African classrooms lack the tools needed to implement 21st-century student-centered pedagogies. As a result, the existing learning culture in South African universities could hinder the successful implementation of the flipped classroom model.

*Graph 4.
Preference with Multimedia.*



*Graph 5.
Student-centredness.*



Intentional content

The primary goal of this principle is to align content with appropriate instructional delivery methods (Naidoo, 2020). Furthermore, lecturers must be adaptable enough to transition from traditional teaching methods. In investigating this principle, the study aimed

to understand the types of content respondents were accustomed to and the level of access they had to this content, which is essential for facilitating a flipped classroom model. Most respondents reported using textbooks as their primary source of content. Encouragingly, 47% of respondents indicated that they could access these textbooks outside the classroom, suggesting that lecturers could direct students to engage with content outside of class, thereby freeing up class time for more practical activities. However, nearly 60% of respondents stated that they could not afford these textbooks, which poses a significant barrier to implementing a flipped classroom model. Many students at underprivileged universities in South Africa face financial difficulties when it comes to purchasing textbooks and other educational resources (Goodier, 2019). In an effort to promote equity and support disadvantaged students, the South African government provides funding and resource allowances. However, Goodier (2019) notes that these funds are often used to support extended family members struggling with poverty, rather than being spent on educational materials. If communities in South Africa could meet the basic needs of students, this would allow allocated funds to be used for purchasing the educational resources necessary to implement a flipped classroom model.

*Graph 6.
Access to content resources.*



*Graph 7.
Affordability of content resources.*



6. CONCLUSIONS AND RECOMMENDATIONS

While this study was limited in its capacity to fully understand all South African universities, the exploration of a previously disadvantaged South African university, combined with existing literature, provided insights into the broader South African context. The findings revealed that historical inequalities and the current state of South African

communities and universities present significant barriers to the effective implementation of the flipped classroom approach. The study recommends a collaborative effort between the Department of Higher Education and Social Services to 'flip communities' first before flipping classrooms. In this regard, universities should prioritize their community engagement initiatives to create environments where students can live and study effectively. Additionally, universities must ensure that students living in off-campus accommodations have access to appropriate resource centers and educational facilities to support their academic pursuits. South African universities cannot afford to fall behind in adopting innovative 21st-century pedagogies due to contextual challenges and barriers to accessing content.

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Chapter # 20

WHAT CHATBOT SHOULD SUPPORT NOVICE INSTRUCTORS IN ASSISTING STUDENTS IN PBL PRACTICE

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ABSTRACT

"Reflection-Bot" is a chatbot originally designed for daily journaling in self-directed language learning, with features that promote goal setting and reflection through personalized notifications. In the present paper, we explore the potential of utilizing this chatbot for students' weekly learning supports in a PBL course through an analysis of interview data from several new instructors. The results highlight various issues with the PBL course as currently practiced, such as inadequate instructional time for students, lack of intervention training for instructors, and underestimation of the importance of intervention. We show that if we add to the existing chatbot the ability to intervene for students' learning on behalf of instructors or to show instructors how to do that could potentially solve some of the issues.

Keywords: project-based learning, self-directed language learning, reflection of learning, chatbot.

1. INTRODUCTION

1.1. Question-Prompting Chatbot for Self-Directed Learning

It becomes crucial in global language policies to promote Self-Directed Learning, here and hereafter SDL (Knowles, 1975), and leverage assistive technologies. SDL requires students to possess a variety of learning readiness (e.g. Guglielmino, 1978; Stockdale & Brockett, 2011; Oddi, 1987), among which identifying learning needs, setting goals, selecting strategies, and evaluating outcomes are important elements. Many universities in Japan offer training programs to help students become better learners during their first year of study (e.g., Matsuba et al., 2023). The objective of the programs is to cultivate learners' readiness for SDL, with a particular emphasis on fostering their ability to set and reflect on learning goals.

Because second language acquisition is a complex and long-term process, it is essential to build the learner's independent study that is skills. To achieve personal goals, Japanese language learners need to develop the ability to set their own objectives, select relevant materials, and define learning pathways. Providing structured guidance alongside opportunities for independent, self-directed learning under instructor supervision can significantly impact learners' future learning positively. However, the lack of comprehensive guidelines to support their development makes it challenging for instructors to provide sufficiently effective guidance to learners.

The lead author and her coworkers are conducting educational developmental research in order to establish an activity model for Japanese as a second language courses at the university level. This Self-Directed Language Learning (SDLL) model is designed to enable

students to naturally engage in SDL and develop these skills for continued success in their future learning endeavors (Kai, Matsuba, Goda, Wada, & Suzuki, 2020). The SDLL model was designed and refined based on a Design-based Research framework (McKenney & Reeves, 2019), includes practicing Japanese outside classroom, journaling about the experience, and engaging in reflective activities within classroom. We examined the design requirements and proposals for the activity, created a skeleton design, and developed the supporting tool. For learners of Japanese as a Second Language, the language is an integral part of their daily lives. The need to learn and practice Japanese naturally arises from everyday experiences. Consequently, setting specific goals should be guided by reflections on their daily language use. In SDLL model, learners break down their learning goals into achievable weekly tasks during the course and create weekly objectives and plans. They are required to record the outcomes of their efforts, ideally daily but at least three times a week. At the beginning of the next module, the learners go over their weekly logs and reflect on their progress. Then, they discuss with peers about their reflections or consult with instructors to improve their plans for the next week. Our learners give a formal presentation at the midterm and end of the semester to share their self-evaluations of how effectively they carried out their learning plans and met their learning objectives. This model is based on the diary method, which is considered an optimal approach for fostering reflection and goal setting (Brandt, 2020). We recognize the approach to be effective in supporting this type of SDL. The most challenging aspect of this activity for the learner is keeping a consistent daily diary. (e.g., Saito, Miyake, Fukushima, Suzuki, & Imai, 2009).

In recent years, chatbot systems with various features have been actively employed in many educational fields like language learning and nursing in higher education to meet the needs of students in the fields (e.g., Fryer, Nakao & Thompson, 2019, Studente & Ellis, 2020). However, initial implementation results revealed that a standalone portfolio system hardly encourage learners to maintain daily records. To improve the effectiveness and feasibility of this activity model, Kai et al. (2020; 2024) also employed a chatbot system, and developed an original "Reflection-bot" system to support the continuous recording of learning experiences. Two key aspects emphasized during the system's design phase are to lower the barriers for learners to journal their learning experiences, and to provide reminders they would not forget to do so. We adopt "LINE" system (<https://line.me/en/>) as the platform for "Reflection-bot." "LINE" is one of the most popular communication applications in East Asia, which holds nearly 100% market share among Japanese university students. We expect that incorporating a chatbot into the social networking platform most familiar to learners and allowing them to write entries using the same user interface would greatly improve accessibility. In addition to simplifying the process for students to submit reflections on the LINE social networking platform, this solution integrates LTI (Learning Tools Interoperability) to store these entries in a LMS (Learning Management System) at the same time. Thus, it successfully accomplishes two goals: giving students an easy-to-use method to write entries and allowing them to see their records through the LMS in class, which eventually helps them build a thorough learning portfolio.

The "Reflection-bot" implements the function of sending a series of questions predetermined by an instructor to their learners ("What was the most impressive thing you learned today", "Why", etc.) and recording their responses. Instructors can use a web-based administrator settings page to customize the chatbot's question items and set other features. Once configured, the chatbot can be distributed to learners, who register it in their LINE accounts by scanning a QR code. In order to address the need for providing reminders, the chatbot features customizable notifications, letting learners set own timing. It is the unique feature among similar systems. By allowing learners to choose when they receive prompts,

the system smooths the transition from notification to recording. It keeps a balance between respecting and encouraging learner autonomy while providing the structure necessary for consistent and thorough documentation. The study for empirical validation of the system has indicated the ability to vary notification times for each learner. It not only holds higher rates of continuous record-keeping, but also expands the ability to conduct meaningful reflective activities based on the records that lead to improvement of their own goals consequently (Kai et al., 2020). To evaluate the applicability of our activity model and design principles with this chatbot, we have carried out it in a university introductory Japanese language course. As a result, we confirm that learners' reflections and goals became more specific and clearer (Kai et al., 2024). In parallel, with the evolution of generative AI, Kai and Wada (2023) implemented a parameter setting function for generative ChatGPT into the chatbot, which also enables us to output comments corresponding to learners' input. In this way, the chatbot continues to be developed to support an enhanced SDL experience.

1.2. Purpose of the Present Study

We assume that the unique chatbot described above can be used for goal-setting and reflection help in a variety of sectors, in addition to language acquisition. It has been demonstrated that the chatbot created by Kai et al. (2020; 2024) is quite successful at gathering reflections on daily learning experiences and carrying out weekly meta-reflections. Its capacity to facilitate learning activities over a longer time frame, such keeping track of weekly activities and carrying out meta-reflections on a semester basis, hasn't been adequately assessed, though. Thus, our goal is to investigate how this chatbot can facilitate other educational types of weekly activities. As a first step in our study, we conduct an exploratory survey to newly hired instructors of PBL (Project-Based Learning) courses.

2. METHOD

2.1. Survey Subject

During the various weekly activities, this study focuses on PBL as it incorporates multiple aspects of SDL. We consider that the approach described above also works beneficially in PBL, an increasingly popular teaching method worldwide (Ishida & Matsuba, 2019; Guo, Saab, Post, & Admiraal, 2020). In PBL, students are required to set project themes and goals, which necessitates the ability to define their own learning objectives. As the project progresses, the students need to create schedules and divide tasks, demonstrating autonomy in planning and execution. Additionally, PBL requires the students to independently search for necessary information and select appropriate resources. After the project concludes, the students are also commanded to evaluate their outcomes and reflect on the process. Thus, PBL involves stages of planning, preparing, learning, reflecting with the students expected to actively manage these stages. This makes PBL a learning model that supports SDL. For the students become proficient in SDL, instructors can provide assistance if the students are not yet fully independent. To track each student's progress and reflective thinking, instructors typically have the students write reflections after each activity of the PBL practice (Waguri, 2010). However, instructors often encounter reflections of less-than-ideal quality. The instructors sometimes do not take feedback on these reflections seriously and simply mark them as "READ". This slight lapse, in addition to student dissatisfaction, can lead to a decline in the quality of the reflective writing more. We predicted that the primary reason for this situation is the scarcity in both quality and quantity of reflective records, which are essential for effective tutoring in student goal setting and project

progression. We consider the situation could significantly improve by introducing our activity model with our chatbot, which would enable students to produce more meaningful reflections. This, in turn, could enhance the quality of tutoring and subsequently improve students' learning outcomes.

The common activity between self-directed language learning model mentioned above and PBL is to write reflections on the set goals. We conducted this exploratory study with the help of newly hired instructors affiliated with a college of KOSEN (National University of Technology in Japan) offering a large-scale PBL program annually, because we hope to know what pedagogical interventions provided by novice instructors in the PBL practice when they firstly engaged, as well as the challenges they faced, in order to support SDL (Ishida, Takeoka, Kajimura, & Matsuba, 2018). It is expected that the study can not only reveal the intervention methods that the instructors use to assist their students and the challenges they face in doing so but also clarify the potential of chatbots in supporting the setting of learning goals and reflection in PBL practices. In the rest of this section, we briefly introduce the PBL program offered at the college of KOSEN.

The offering program is mandatory for all students from the 2nd to the 4th grade across four departments: Mechanical Engineering, Electrical and Computer Engineering, Urban Systems Engineering, and Architecture, with a total enrollment of approximately 500 students. The students usually take three distinct projects for six semesters, or three years, until they graduate. They are grouped into diverse teams across grades and departments, then work on selected year-long projects under an instructor's guidance in the program. They are not allowed to choose their team, but they can voluntarily choose the project theme they will work on in this program. There are about 60 teams in all, and each team has one support instructor. The support instructors are not expected to oversee their students' activities in-depth or provide them with task instructions. Rather, the instructors are supposed to offer educational interventions in response to requests from their students or when they notice a specific need among the team members.

Each semester consists of three phases: Orientation, Main Activities, and Wrap-up. During the orientation phase, the students engage in activities designed to understand the course structure and get to know their team members. In this phase, the instructors first provide a lecture on the course objectives, the activities to be undertaken, expected outcomes, and key personal achievements. The achievement goals outlined in the syllabus are 1) to be able to self-regulate, 2) to work in own teams while respecting others, and 3) to be able to collect and organize information, identify issues, and make proposals. At the beginning of each semester, the students set individual goals, aligned with these achievement goals (autonomy, collaboration, and creativity), which are evaluated throughout the course. At this point, the support instructors review students' self-set goals and action plans. Then if they need a guidance for their students, they have a closed meeting with the students to provide it and request revision of the outcomes. Subsequently, the students define their team's theme tackled through two semesters. The theme is strongly required to meet the following conditions: it should benefit someone, pose a challenge for the team, and align with one of the 17 Sustainable Development Goals usually noted as SDGs. After setting theme, the team members are assigned own roles and make an action plan for the semester.

In the final phase of each semester, the students critically reflect on their performance with a rubric for self-assessment. The rubric is organized around three major objectives, each divided into three specific criteria, totaling nine criteria, which include goal-setting and reflection. They evaluate their performance on each criterion using a five-level scale, from Level 0 (lowest) to Level 4 (highest). Additionally, for each major objective, the students select one criterion they particularly wish to focus on and create an action plan outlining the

steps they will take to achieve this goal. These aids like rubrics or self-reflection sheets empower them to critically analyze own performance, aligning their understanding and skills with the course objectives.

2.2. Collected Data

A report containing verbatim transcripts from an interview survey conducted with novice instructors at the college of KOSEN (Ishida, Mizushima, Tanaka, Suzuki, & Matsuba, 2024) was selected as the appropriate data source for this analysis. This data, provided by the second author, who implemented the survey, was obtained in accordance with the provisions of the GDPR, and all data has been anonymized for analysis. There are no ethical concerns.

2.3. Survey Procedure

The purpose of the interview was to explore how newly hired instructors assist students in setting goals, implementing projects, and reflecting on students' progress. Written explanations concerning the survey objectives, data handling, and related matters were provided in advance to all new instructors in their first to third year of teaching PBL at this college of KOSEN, and six instructors agreed to participate. The interview was conducted through pre-surveys via Google Forms and semi-structured interviews in November and December of 2022, coinciding with the wrap-up phase of the second semester of the year. The pre-survey questions were organized in a chronological order to help participants recall the content of their teaching practices, following the PBL process. The pre-survey included the following question items:

[Orientation phase]

- ☞ Do you believe that students improved their ability to set and reflect on goals?
- ☞ At which phase did you intervene with advice or guidance in this course?
- ☞ Did you have students set personal goals (in the first or second semester)?
- ☞ Did you provide advice, and guidance, or require revisions during the goal-setting phase?
- ☞ Did you encourage the use of a workbook during the goal-setting phase?

[Main Activities phase]

- ☞ What strategies did you employ to facilitate smooth learning activities for the students?
- ☞ Did you instruct students to write weekly reflection sheets?
- ☞ How frequently did you review the content of the student's reflection sheets?

[Wrap-up phase]

- ☞ Were you able to conduct interviews with the students at the end of the first term?
- ☞ How much time did you spend on interviews per student?

The interviews were based on the contents of the pre-survey to further investigate these topics. The interviewees were interviewed for about 90 minutes each. First, they were asked whether they had taken actions such as encouraging students to read the workbook at each stage. If there were interventions, the interviewers inquired about the specifics of the intervention, the use of resources or aids provided (worksheets, senior instructors, etc.), and the outcomes of such interventions. If there was no intervention, the reasons for not intervening were explored. They were also asked about any overall challenges or issues faced. Additionally, to understand the instructors' values, the perceived frequency of the need for advice and guidance was also discussed. With the transcribed interview data, the second author, who is most familiar with the college of KOSEN's PBL, performed the primary content analysis aligned to this research objectives and extracted relevant parts related to the subject matter. Subsequently, the other authors reviewed the data and conducted analyses from the perspective of this study, shared their results, and adjusted the criteria for judgment in case of disagreements. Due to the small amount of data, inter-rater reliability coefficients were not calculated for the purpose of evaluation adjustments.

3. RESULTS

We present below the results of our analysis of the hearing investigation. It was found that most of the instructors were not actively intervening in students' goal setting and reflection. Time constraints and lack of knowledge about intervention methods were cited as the main reasons. Some instructors also complained that students set low self-evaluations.

Three of the interviewees reported that they can observe the growth of their assigned team members for goal setting and writing reflection. All interviewees were instructed to set personal goals for the students in their charge during the orientation phase, and four of them used the workbook to do so, but only one interviewee stated that she used the workbook effectively to provide specific guidance to her team members. We asked the instructors, who did not give any advice to their students, the reasons for this. The responses indicated that some of them felt unable to intervene at an early stage when they did not know their students well or did not recognize the need for advice and guidance regarding their students' personal goals. One respondent expressed frustration over his students' tendency to set goals below their actual capabilities. In response to a question about planning team projects, half of the interviewees implemented some form of intervention particularly focused on building relationships among team members and assigning roles. Other respondents except one provided some advice or a guidance at the very least. The reasons for offering the advice included the goals not meeting established criteria, the potential for future challenges if students failed to reach a consensus, and the advisability of planning activities in advance when coordinating with fixed-date college events, such as a college festival. Other interventions at the first stage were primarily related to team building, like ice-breaking activities and senior students guiding the juniors. Three respondents instructed their students to complete reflection sheets weekly during the main activities. However, only one consistently reviewed the reflection sheets. The other two respondents reviewed the sheets only at the end of the term, while the remaining three did not review them at all.

It was illustrated that the reasons why they provided for not utilizing the reflection sheets as follows:

- ☞ Although the benefits of completing the reflection sheets were explained during the orientation phase, I would not check the content, leaving it to the students to decide whether to use them. Based on observations during the classes, it seemed that likely none of the students were writing them.
- ☞ There was neglect in reviewing the reflection sheets.
- ☞ As the hands-on work became more intensive, finding time within the class to complete the reflection sheets became hard.

Another common intervention included asking about the activities and outcomes at the end of each week (5), providing encouragement when activities were stagnant (5), and encouraging active participation from students (4), where the number in parentheses is the number of respondents. All six respondents had individual meetings with their students in the summary phase. The average meeting time was around 9 minutes, ranging from 5 to 15 minutes, with the most common duration being 10 minutes. The focus of the consultations was to convey evaluations from the team members and from the instructor. As we conclude this section, we show some characteristic comments about challenges or difficulties identified in the interviews:

- ☞ Finding it challenging to guide senior students who believe they are performing well.
- ☞ Finding a loosening of the students' tempers around the second month of the first semester.

- ☞ Struggling to determine the appropriate level of control an instructor should exert in this course, which emphasizes student autonomy.
- ☞ Deciding on intervention methods when progress stalls.
- ☞ Noticing a tendency for compromise among senior students who are taking the course for multiple times.
- ☞ Wondering how I should suggest students who intentionally give low self-evaluations at the beginning to produce growth.

4. DISCUSSION

The purpose of the present study was to identify teaching practices and issues faced by novice teachers engaged in a PBL practice as a preliminary step to examine whether our chatbots used in daily Japanese SDL activities can be applied to PBL with weekly activities for a semester-long. There are some common learning activities between Self-directed Language Learning (Kai et al., 2024) and PBL like writing reflections on set goals. We identified through the interview data a shared challenge in both educational practices is the issue of students not consistently writing reflections. When instructors require students to write reflections outside of class due to limited class time, some may forget to complete the task. Simply assigning it as an out-of-class activity is also unlikely to solve the problem of superficial or incomplete reflections. While we judge the simply adjusting notification function to a weekly schedule does not fully resolve the above issue, the user-friendly writing interface and reminder feature designed in our chatbot could be part of the solution to mistake for continuous journaling at least.

The interview data indicate that there is little of active intervention of the instructors during the PBL practices, despite the instructors recognize a lack of improvement in this ability among students. This finding corroborates our initial hypothesis presented at the outset of the paper. Almost all the participants of the interviews indicated that their lack of time is the reason they did not or could not provide educational interventions during the progress of their students' projects. Nevertheless, they have consistently fulfilled their responsibilities, such as supporting students in setting learning goals at the beginning and meeting with them at the end of the term. In addition, all, except for one individual, have been able to intervene as needed, such as managing their time and encouraging their active participation since the orientation phase. It would not be difficult to find enough time for instructors to encourage students to write reflections, so we do not doubt that there are other causes for the lack of active educational intervention. We interpret the data as indicating that new the instructors are willing to try to intervene in simple tasks and problems that are easy to commit to through previous experience, but tend to be hesitant to commit to students because of a lack of effective intervention methods or poor understanding of learning processes such as "goal setting and reflection". Another probable explanation for the neglect of "goal setting and reflection" is the small number of teachers, unfortunately including some senior faculties, recognize the value of developing this ability. It substantiates the perspectives that, as we show above, the instructors' statements about uncertainty for the scope of the intervention and that the students intentionally provide low self-assessments.

It is easy to assume that the reluctance of the new instructors due to their inexperience would be improved by emulating the interactions with students of experienced adepts that is senior instructors. As part of the support for the new instructors, the program assigns a senior instructor to be present in the same room to continuously address questions and clarifications in the college program. In addition, there is the PBL practice guidebook including templates for each student activity developed by the program administrators and made available to all

assigned instructors (National Institute of Technology Akashi College Active Learning Center, 2022). The document is a compilation of the overall course flow, learning activities and the role of the instructors based on the findings of learning science research and the knowledge of the administrators, i.e. the experienced instructors. The interview data points out that they appear to receive advice from the experienced instructors to the same classrooms as required, but not to the extent of actively imitating the adepts. Despite having access to the guidebook, the new instructors are not fully utilizing the formats, like the weekly reflection sheet even though they are aware of their existence. The underutilization of these resources suggests not only the possibility that the provided aids may be insufficient, but also that instructors may not perceive them as valuable enough to use. From the present study, we found that new instructors are not able to make good use of resources based on the knowledge possessed by the adepts, i.e., proficient instructors. One of our challenges for the future is how to promote the transfer of knowledge from the adepts to newcomers and how to implement the education of the newcomers.

Do you think whether our chatbot can improve these situations for the new instructors or not? As you can be easily predicted, most of the issues described so far can be attributed to the inexperience of the new instructors in PBL practice. The introduction of a chatbot for student supports in PBL practice is expected to solve many issues caused by inexperienced instructors at a certain level. We envisage that the chatbot's support will guide both students and instructors in three key areas. The first direction is 'Goal Setting and Reflection,' where the chatbot helps students set clear and achievable goals. The key here is to provide questions that allow the students to reflect on the phases of the project in their reflections each time. Second, a chatbot intervenes on behalf of the instructor at each predefined milestone in the program, such as determining the team's theme, creating a team activity plan, and so on. In response to the chatbot's intervention, the instructor assists the students solve their problems, which also encourages relationship-building between the instructor and the students. The last direction is the use of the chatbot in creating the instructor's coaching portfolio. PBL practice, as we discussed before, requires instructors to have coaching skills rather than teaching skills. It is anticipated that the most effective method for skill acquisition is for instructors to improve their coaching skills through self-coaching during practical training in a PBL program. We are confident that both instructors and students will recognize the importance of enhancing this capability through 'goal setting and reflection.'

5. CONCLUSION

In the present paper, we have investigated the potential of the chatbot originally designed for language learning to broader applications in SDL settings and, particularly explored the challenges instructors faced in implementing educational interventions during different practical phases in a PBL framework. Objectively, we argue that the issues identified here are generalizable and applicable to any organization that implements PBL practices. Many of instructors, especially the inexperienced, lack coaching skills for intervention effectively in goal setting and reflection. They tend to rely on personal educational beliefs rather than on systematic and logical methods based on the rules set forth by the program management team or the results of learning science research. We suggest that the reluctance of new instructors due to inexperience can be improved by emulating the behaviors relate with students of experienced seniors. If we provide sharing successful case studies and insights via an ICT system, i.e. chatbot, could quickly enhance their intervention capabilities.

The study identifies three main issues: instructors' failure to recognize the need for educational interventions, uncertainty about the appropriate intervention methods for each phase of the students' activities; and the challenge of finding sufficient time for effective intervention. In the college of KOSEN practice explored here, the students of the program are required to monitor the progress of their projects and reflect on their personal growth. Time constraints, unfortunately, make it difficult for instructors to provide adequate intervention, and, as a result, they end up having to prioritize teaching over other activities. Facilitating reflection and ensuring instructors have access to students' reflective records before class can help in preparing effective intervention strategies. However, it is also true that such analysis and planning is time-consuming, and some technical assistance is acquired to reduce the burden on instructors. We expect that our proposed chatbot will play a major role in solving the issue. The system will help students keep track of their activities, both in and outside of class, so that they can easily access the recorded information whenever they need it.

We expect that the improvement of the functionality of our chatbot by integrating it with the instructional case database so that it can also be used as an instructional support chatbot. It would be useful for instructors in charge of PBL practice, especially newcomers, to develop their own student support skills in practice by creating a coaching portfolio as we showed before. We also consider that the system will not only allow the instructors to propose pedagogical interventions when supporting PBL projects, but also serve as a thought-provoking, or reflective, interlocutor for their portfolio work. As usual, such instructor interventions are optional and often limited to those with sufficient time and motivation. To encourage more proactive engagement, the institution could formalize these interventions and require outcome reporting, while ensuring this process doesn't overly burden instructors. It is essential to foster intrinsic motivation by showcasing the positive impact of interventions through instructor exchanges and student feedback. If the chatbot can collect students' reflective records and refer to similar cases in the case database to suggest appropriate interventions, instructors can then use these suggestions for their educational interventions. The outcomes of these interventions can be fed back into the database as new insights, creating a beneficial cycle. Such a cycle is essential for enhancing instructors' motivation by providing them with practical, evidence-based strategies for intervention. We recognize the need for this positive feedback loop and will continue to consider enhancements to our chatbot's functionality to facilitate this process.

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Chapter # 21

STRENGTHENING THE UNIVERSITY-COMPANY PARTNERSHIP A Collaborative Design Project

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ABSTRACT

On a global scale, universities today are increasingly expected to enrich their curriculum with real-world learning experiences to increase student engagement and cultivate students' critical social competencies. The topic of collaboration between universities and companies has been extensively debated, and there is a widespread acceptance of the notion that companies can genuinely contribute to teaching content by sharing cutting-edge knowledge, expertise, and resources. In this chapter, the authors examine the discrepancy between universities and companies in the design field to identify viable strategies to enhance collaboration between these sectors. The authors provide a design project conducted in partnership with a prominent global company as a case study to illustrate the effectiveness of such initiatives in closing the gap between universities and companies. The authors aspire to furnish fellow researchers in cognate fields with a valuable reference point, informed by the experiences gained from this project, to explore further and enhance design practice, achieving more substantial and consequential outcomes.

Keywords: university-company collaboration, design practice, design education.

1. INTRODUCTION

The global higher education landscape has recently navigated the challenges posed by the pandemic, prompting a return to pre-pandemic norms. However, this transition is not without substantial challenges, as the academic realm undergoes a paradigm shift driven by the imperative for business reinvention, heightened workplace requirements, and evolving student aspirations (Euromonitor International, 2022). In recent years, a discernible emphasis has emerged on fostering stronger linkages between university and company, particularly within the dynamic design sector, necessitating effective collaboration to prepare a competent workforce capable of sustaining internal company capabilities (Burnside & Witkin, 2008). Oliver, Montgomery, and Barda posited that the innovative university-company partnership is based on “interactions between university and industry scientists working on translating academic science with commercial potential towards market applications” (2019, p. 759). Deloitte's research (2017) also emphasises that business acumen will be deemed an invaluable proficiency alongside creativity and innovation for designers, identified as a critical success factor for dynamic performance across industries. McKinsey & Company (2018) further asserts that companies with optimal financial returns embrace a design-centric vision, highlighting the urgency of enhancing the interconnectedness of design and business in contemporary education.

Traditionally, the university prioritises theoretical knowledge dissemination, while the company focuses on profit-driven product development. When these two realms converge in a synergistic collaboration, each will discover shared interests to establish a sustainable mutually beneficial outcome. Regrettably, this exemplary partnership is not commonplace. A disparity consistently exists between university instruction and industry practice. The university serves as an external network for the enterprise, playing a crucial role in facilitating the industry's progress and development. The substantial shift in design industries has rendered good academic-industrial collaboration increasingly essential. As the world evolves, the design sector and academic institutions must adapt their strategies. Developing an appropriate workforce for the industry necessitates ongoing and productive communication between academia and the professional sector. Instead of staying in an insular world, universities must transform and reinvent themselves to adapt to the sector's new realities and rectify the theoretical knowledge into up-to-date practical industrial issues to equip graduates with adequate skills and competencies. Research undertaken by Bocconi University in 2016 indicates that talent mismatch may contribute to substantial losses in Italian GDP and elevated unemployment rates. Due to the divergent motivations of universities and companies, challenges in interpreting and valuing shared objectives are unavoidable (Siegel, Waldman, Atwater, & Link, 2003). Achieving a shared contextual comprehension among diverse stakeholders has emerged as a primary problem in bridging the university-company divide (Wallin, Isaksson, Larsson, & Elfströms, 2014).

In this chapter, the authors introduce a design project, illustrating effective solutions to fortify the university-company ties. The authors provide insights into the interplay between academic research and design practice through unique perspectives, offering strategies to integrate these domains for innovation and knowledge advancement. The authors anticipate that the experiences shared in the case study will serve as a valuable reference for fellow researchers, encouraging a comprehensive exploration of design practices and yielding more impactful outcomes.

2. A COLLABORATIVE DESIGN PROJECT WITH MIDEA

2.1. Beyond the Formal Curriculum

In the book *The Curriculum*, the educationist Bobbitt (1918) suggested that education should be concerned with both directed and undirected curricula for completing and perfecting the individual's abilities. Like his idea, Goodson (1995) also suggested that the curriculum should not be too narrowly focused not to restrict learners. Leask (2015) declared it would be helpful to consider the curriculum's "formal, informal, and hidden elements" (p. 8) when shaping lived experiences for all students. "Passion in Action" is an initiative the Politecnico di Milano offers, integrating directed and undirected training experiences to enhance students' abilities, attitudes, and appreciation.

Passion in Action is a catalogue of instructional activities that anybody may participate in. These activities are designed to help students build skills that can be used across many areas, such as communication and teamwork. The goal is to inspire and assist students in broadening their personal, cultural, and professional experiences. The training and educational activities are intended to be interactive, pragmatic, and captivating, enabling students to get fresh insights and establish significant associations with peers in their respective domains. The following activities are included:

- The short courses on transversal tools and processes: provide students with a thorough comprehension of diverse tools and techniques crucial in today's dynamic and continuously changing business landscape. The courses are structured to be concise and concentrated, enabling students to rapidly gain fresh skills and information within a short duration.
- Designing exercises in interdisciplinary domains: enhance students' capacity to engage in creative and critical thinking when faced with intricate situations. The multidisciplinary events promote cooperation among students from many areas and backgrounds. This educational setting might greatly benefit students looking for fresh insights on a specific topic or issue.
- Collaborative initiatives with enterprises: allow students to use their skills and knowledge in a practical, real-life context. The projects are conducted in partnership with businesses, enabling students to get hands-on experience and cultivate professional connections. Collaborative projects in a group setting may help develop cooperation and collaboration abilities, crucial competencies in the 21st century.
- Hackathons and contests: motivate students to use their expertise and understanding to address practical issues in the real world. These activities provide a stimulating setting where students may test the limits of their abilities. Competitions and hackathons give students a distinct chance to connect with their classmates and experts and get acknowledgement for their accomplishments.

2.2. Midea Design Workshop

The Midea design workshop is one of the great educational activities offered in the Passion in Action catalogue. It presents a unique opportunity for students to hone their skills and develop an understanding of the design discipline. This design practice demands that students integrate their interdisciplinary knowledge of design principles with their creativity to craft solutions dedicated to the Midea products. This trial challenges students' ability to collaboratively develop aesthetically compelling and practically effective designs applicable across various design contexts.

Midea, situated within the home appliance sector of the Midea Group, an eminent global high-technology enterprise holding the 245th position in the 2022 Global Fortune 500 ranking, encompasses a diverse portfolio of over ten brands. Aligned with the overarching ethos of "Humanising Technology" shared across all Midea Group businesses, Midea's operational philosophy prioritises consumer-centricity and proactive problem-solving. The company is committed to exceeding current expectations while anticipating and addressing evolving consumer needs through continuous exploration and innovation. Under the Midea Home Appliances brand, the company presents an extensive array of products within the home appliance industry, specialising in air treatment (encompassing both commercial and residential air conditioning solutions), refrigeration, laundry, large kitchen and cooking appliances, small kitchen appliances, water appliances, floor care, and lighting. This comprehensive product range underscores Midea's dedication to offering multifaceted solutions to the dynamic requirements of consumers, thereby positioning itself as a significant player in the global market (Figure 1).

Figure 1.

Left: Midea logo. Right: A Midea water dispenser product for the Chinese market.



2.3. Design Workshop Objectives

The workshop focuses on enhancing the market presence of Midea's ICE-BANK enabled SODA water dispenser in Europe, encouraging adoption by addressing both functional and emotional aspects. The product under consideration represents the latest development by Midea, featuring a distinctive attribute known as ICE-BANK, facilitating an uninterrupted supply of chilled carbonised water. The primary functionality of the product lies in delivering purified water, chilled purified water, and chilled carbonised water. It is important to note that the platform is fixed and immutable. The company must enhance its market standing in Europe, incentivising consumers to adopt the SODA water dispenser. This strategic move aligns with the growing significance of SODA and purified water dispensers in mitigating the environmental impact associated with plastic bottle consumption, transportation, and storage.

Given the escalating popularity of water purification systems and evolving perspectives on SODA utilisation in various contexts (e.g., social gatherings, culinary activities, health-conscious practices), the workshop sets forth the following objectives:

- Collecting pertinent data and information concerning the European market to identify potential innovative scenarios.
- Propose design solutions that capture customer attention by enhancing visual engagement with the SODA function.
- Strengthening the overall user experience associated with the SODA water dispenser.
- Augmenting the visualisation and perception of the dispensing process, mainly focusing on the user interface (UI) aspects.

Specifically, the workshop aims to address the following thematic areas:

Visual Engagement:

- Strategies for effectively communicating and showcasing the SODA function in retail settings.
- Design expressions that convey the SODA function and emotionally engage potential customers.
- Techniques to evoke interest and prompt purchase decisions.

User Experience (UX) Physical Interaction:

- Improving the overall user experience during the SODA dispensing process.
- Enhancing interaction aspects during maintenance operations.

- Addressing considerations such as the type of vessels used, timing of usage, and diverse user needs.

UX Interface-UI:

- Exploring methods to engage users emotionally in the SODA process.
- Enhancing user interface design to improve the overall utilisation of the SODA dispenser.
- Encouraging users to perceive SODA as a compelling beverage choice through thoughtful interface design and interaction.

2.4. Design Team Structure

The design team comprises a diverse and multi-disciplinary group of professionals with varied design expertise. Senior professors with substantial knowledge in the relevant field oversee the scientific direction. Complementing their leadership, mentors, junior designers, and structured researchers contribute with their distinct perspectives and approaches to the project. The six operational groups consist of 19 master-level students of international origin, hailing from different countries and possessing diverse design backgrounds. These students were selectively chosen from the School of Design at Politecnico di Milano and POLI.design, the consortium founded by Politecnico di Milano. In addition to the academic constituents, corporate partners affiliated with Midea play a pivotal role by imparting invaluable contributions to the project. This contribution involves sharing technical specifications, offering suggestions, and infusing artistic and creative inputs. The collaboration extends beyond academic boundaries, fostering an international and interdisciplinary environment that facilitates the generation of innovative and cutting-edge ideas within the design team. This collaborative effort provides a unique learning opportunity for students and enables them to glean insights from experienced professionals in the field (Table 1).

Table 1.
Design workshop team structure.

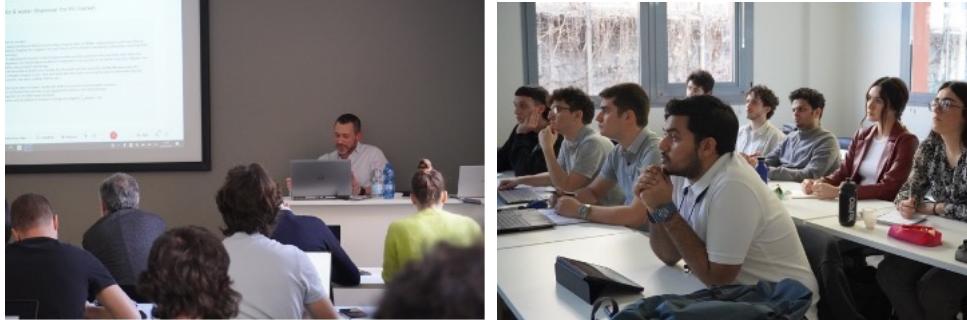
		Scientific Direction: Senior Professors from the Politecnico di Milano, School of Design, highly qualified in the relative field.
		Mentors: Junior Designers/Structured Researchers from the Politecnico di Milano, School of Design.
		Working Team: 19 international students selected from Politecnico di Milano, School of Design, and POLI.design.
		Corporate partners from Midea, bringing contributions of their technical specifications/indications/artistic/creative inputs.

2.5. Design Workshop Process

The workshop began on the 24th of March 2023 and concluded on the 15th of May 2023, followed by three stages.

Initiation and briefing: The first stage of the design process involves comprehensive project initiation and briefing. The design team thoroughly examines the project's requirements, objectives, and contextual constraints at this step. A clear understanding of the company's expectations and the broader socio-cultural context is established. This stage necessitates effective communication between the scientific team, corporate partners (experts from Midea), and design students to ascertain project goals, constraints, and any specific considerations that may inform the subsequent design phases (Figure 2). Empowered with this foundational knowledge, participants have embarked upon the critical step of discerning and delineating the fundamental problem statements inherent to the project.

Figure 2.
Project initiation and briefing with Midea representatives.



Design development: After the briefing phase, the design process advances into the conceptualisation and design development stage, marked by synthesising ideas, exploring design possibilities, and formulating preliminary design concepts. In the second phase of the workshop, a studio-based collaborative approach is systematically employed to assess the quality, feasibility, and alignment of design concepts with the specified project objectives. This pedagogical strategy is rooted in an intersubjective exchange between students and their academic mentors, embodying a democratic and open collaborative ethos. It fosters the seamless transmission of knowledge while concurrently catalysing the emergence of innovative pathways toward expertise cultivation. Within the studio-based framework, students are actively encouraged to participate in experiential learning, applying theoretical knowledge to practical design challenges. This pedagogical environment facilitates an iterative process wherein the initial, ambiguous understanding of product requirements gradually transforms into refined and superior outcomes, aligning with the observations of Green and Bonollo (2003).

A critical stage of this phase entails the active involvement of Midea representatives, who are invited to participate in the mid-term presentations. Within this collaborative context, students have the distinctive opportunity to articulate and present their evolving design proposals, thereby opening themselves to constructive critique and invaluable feedback from industry professionals. Collaboration and feedback loops among team members and stakeholders throughout this stage are crucial in refining the design concept before the finalisation phase.

Final delivery: The design workshop's conclusive phase involves refining the proposal and developing comprehensive design specifications. Students are responsible for presenting their finalised design concepts to a discerning audience of company representatives (Figure 3). This ultimate stage represents a valuable opportunity for students to subject their work to the criticism of industry professionals and mentors. The feedback during this evaluative process prompts profound self-reflection among the students, facilitating a systematic dissection and evaluation of their designs' inherent strengths and weaknesses. Following an intensive discussion and assessment, Midea representatives selected a single proposal that most closely aligned with the stipulated objectives of the project. This chosen proposal is earmarked for further development, ultimately culminating in its finalisation.

*Figure 3.
The final presentations of the project.*



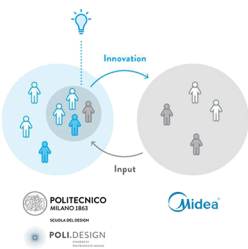
3. OBSERVATION AND CONCLUSION

The correction of the skills mismatch emphasises the need for a consistent alignment of university courses with the ever-changing requirements of the industrial sector. The key focus of this project is to provide a smooth and uninterrupted route that enables graduates to skillfully navigate their career paths and successfully transition into their chosen professions. Spang (2014) argues that it is necessary to establish a flexible delivery model in design education to meet the diverse needs of modern students, deviating from the current traditional approach. The case study presented in this chapter demonstrates the increasing spread of a culture that prioritises design across various academic institutions, professional bodies, companies, and practitioners. Furthermore, creating cooperative alliances inside educational paths is seen as a strategic method that can accelerate the achievement of students' desired goals. Several crucial characteristics are critical to the effectiveness of this framework (Table 2):

- The function of intermediate facilitators: The intermediate facilitators have a crucial role within the complex network of university-company cooperation. These intermediate characters act as intermediaries between the academic and industrial sectors, skillfully managing communication channels and promoting collaborative synergies to achieve mutually beneficial results. Intermediate facilitators are crucial in bridging the gap between academic and company stakeholders by translating their perspectives, goals, and priorities into a common language. They are essential in identifying shared interests and facilitating the exchange of knowledge and expertise between academia and industry.
- Corporate partner serving as a trainer: In an academic setting, the corporate partner takes on a position similar to that of a teacher, with the necessary skills and expertise to encourage active student engagement. The business partner plays a crucial role in fostering student engagement and co-creation as an essential participant in the educational process. Students develop a mutually beneficial grasp of the topic via organised meetings, immersion trips, and thoughtful presentation evaluations, strengthening the academic experience.
- Interactive experience conducted in a studio setting, including active participation from the participants. Prioritising the implementation of studio-based teaching approaches is of utmost importance, with a focus on actively engaging students and cultivating a collaborative atmosphere. Students are not passive receivers but rather active participants who actively influence their learning experience, contributing to

developing their cross-cultural and interdisciplinary views. This teaching method covers the whole range from understanding the project instructions vaguely to achieving an excellent result. It helps students to explore, solidify abstract ideas, and create new methods of acquiring information.

Table 2.
A collaborative partnership within educational pathways.

		Participatory teaching and learning: active student engagement and collaboration to shape new knowledge paths.
		Partner as a trainer: bring external requisite skills and knowledge to facilitate the internal active learning process.
		Intermediate Facilitators: identify common areas and promote the exchange of expertise between academia and industry.

Creating collaborative partnerships within educational pathways is a strategic approach to tackling the skills gap. This involves enhancing the academic journey with substantial experiential learning opportunities, allowing students to develop into adaptable professionals who are well-prepared for the workforce. This method highlights the critical relationship between academics and enterprise, resulting in a balanced and mutually beneficial environment that fosters a skilled workforce capable of navigating the diverse terrain of modern professional practice. This chapter presents a case study that serves as a reference and symbolises a practical approach to strengthening the relationship between academia and the business world. With distinctive viewpoints and profound understanding, the authors provide a knowledgeable account of the interaction between scholarly research and the practical application of design. Their academic insights aim to illuminate the ideal merger of these two domains, a merging that promotes innovation and drives the boundaries of knowledge.

When it comes to modern company operations, establishing an innovative culture is of utmost importance. This culture should encompass active participation in imaginative brainstorming and the solicitation of feedback from outside sources. This approach encourages the development of innovative viewpoints and makes it possible to generate meaning that is in tune with the zeitgeist that is now in effect. The design sector is witnessing rapid expansion, which coincides with the demands of discerning customers who are looking for higher attractions, experiences, and quality. Through talks with partners that are both experts and collaborative, this sector works toward the goal of presenting high-quality products and services that are within reach of the average person and are in line with the cultural vision of producing a new generation of professionals. The reinvention of businesses is already underway, and it will be accompanied by the shifting demands of the workplace and the developing expectations of students. In this regard, enhancing the synergy between design and business and bridging the gap between academia and industry has been deemed to be extremely important in the internationalized era that we are currently living in.

The authors wish to inspire colleagues and scholars in related fields by presenting their experiences and discoveries. Their shared goal is to significantly contribute to the continuous and determined effort to enhance the spirit of cooperation and the creative interchange of

ideas that characterise the interaction between academics and industry. The authors believe that the findings from their case study have the potential to stimulate a more productive and mutually beneficial integration between academic research and industrial design. The consequence of this transformational interaction is expected to provide meaningful results, which will have a favourable effect on several aspects of modern business and academic research.

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Chapter # 22

DIGITAL AND ANALOGUE GAMING IN THE DAILY LIVES OF PEOPLE WITH INTELLECTUAL DISABILITY **A Case Study in the Portuguese Context**

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ABSTRACT

The role of games in promoting cognitive and social development for People with Intellectual Disability (PwID) is increasingly recognised, yet the specific impacts of digital versus analogue games remain underexplored. This study explores the cognitive, social, and emotional influence of digital and analogue games on PwID in Portuguese institutions. Using a participatory design approach, four games – two digital and two analogue – were developed collaboratively between academia and self-advocacy institutions. Semi-structured interviews were conducted with support workers from two institutions in the North of Portugal, who provided feedback based on their experiences of using these games with PwID. Thematic analysis of these interviews identified key themes such as cognitive skills development, social interaction, accessibility challenges, and game design preferences. Results indicate that both digital and analogue games can promote cognitive stimulation and social engagement, though analogue games tend to foster richer peer interaction, while digital games are associated with maturity and autonomy by the participants. The study highlights the importance of customisation and accessibility in game design and suggests future research should focus on longer-term effects.

Keywords: intellectual disability, digital games, analogue games, cognitive development, social inclusion, participatory design.

1. INTRODUCTION

The role of games in fostering cognitive and social development has garnered increasing attention in scientific research, particularly concerning neurodivergent populations, as People with Intellectual Disability (PwID; Derks, Willems, & Sterkenburg, 2022; Sousa, Neves, & Damásio, 2020). The potential benefits of both digital and analogue games have been extensively documented, highlighting their capacity to enhance learning, social interaction, and overall well-being (Barz, Benick, Dörrenbächer-Ulrich, & Perels, 2023; Gallud et al., 2023). However, the comparative impact of digital versus analogue gaming remains a debated issue, particularly in contexts involving individuals with specific cognitive accessibility needs (Atherton & Cross, 2021).

This study aims to contribute to this ongoing discussion by examining the impacts of both digital and analogue games on adult PwID within the Portuguese context. Focusing on four accessible games – two digital and two analogue – developed through a collaborative approach between academia and self-advocacy institutions, this research explores how these games can serve as part of the occupational plans of PwID. By conducting semi-structured interviews with support workers who tested these games with PwID, we seek to critically assess the barriers, challenges, and opportunities presented by both forms of gaming in daily life.

This study is particularly relevant in the Portuguese context due to the unique socio-economic and cultural factors that influence the daily lives of PwID in the country. Portugal, like many other nations, has been gradually improving its policies and practices regarding the inclusion of PwID in various aspects of society. However, significant challenges remain, particularly in the accessibility and availability of tailored educational and recreational resources (Campos Pinto, Fontes, Neca, Bento, & Alves, 2023; Moura & Fontes, 2023). The integration of digital and analogue gaming as tools for cognitive and social development is still in its nascent stages within the Portuguese framework, where resources are often limited, and digital literacy varies widely across different regions and institutions (Sousa, Neves, & Damásio, 2022a; Tymoshchuk, Martins, Almeida, Cartaxo, & Albuquerque, 2022). Moreover, the collaborative approach between academia and self-advocacy institutions in Portugal, as highlighted in this study, reflects an emerging but crucial effort to bridge these gaps (Sousa & Neves, 2023).

1.1. Gaming as Social Inclusion for People with Intellectual Disability

The use of games as tools for social inclusion among PwID has gained significant attention in recent years. This approach provides recreational opportunities and fosters social interaction, enhances communication skills, and promotes a sense of belonging within broader communities (Sousa et al., 2020; Terras, Boyle, Ramsay, & Jarrett, 2018). The potential of gaming to act as a bridge for social inclusion is particularly evident in the way it can support PwID in overcoming barriers to social interaction, which are often exacerbated by their cognitive challenges (Alkahtani, 2024).

Intellectual Disability (ID) is a neurodevelopmental condition characterised by significant limitations in intellectual functioning and adaptive behaviour, including a range of everyday social and practical skills (American Psychiatric Association [APA], 2023). From a neurodiversity perspective, ID is seen as part of the natural variation in human cognition, with a focus on recognising and accommodating diverse strengths and ways of functioning (Robertson, 2009). This approach shifts the focus from “fixing” deficits to fostering environments that support the inclusion of individuals with different cognitive profiles, such as those with ID (Chapman, 2020).

The role of gaming in social inclusion is closely linked to the dichotomy between recreation and more structured activities such as occupational health and inclusive education. On one hand, games offer a recreational outlet that allows PwID to engage in playful, low-pressure interactions that reduce social anxiety and foster enjoyment (Dratsiou et al., 2021; Eldeniz Cetin & Cay, 2020). On the other hand, when integrated into educational and occupational health frameworks, games become powerful tools for developing specific skills, enhancing cognitive abilities, and promoting social inclusion in a more structured manner. This dichotomy reflects the dual potential of games to serve as both leisure activities and therapeutic or educational tools, depending on their context and objectives (Sousa et al., 2022a; Suárez-Iglesias, Martínez-de-Quel, Marin Moldes, & Ayan Perez, 2021; Terras et al., 2018).

1.2. Analogue and Digital Games: Is it Really a Dilemma?

The question of whether to prioritise analogue or digital games in educational and intervention settings is often framed as a dilemma, yet a closer analysis suggests that this dichotomy may be overstated. Both analogue and digital games offer distinct advantages and limitations, and understanding their differences is crucial for educators, game designers, and caregivers when selecting or creating games tailored to the specific needs of learners (Pomichal, 2023; Sousa, Neves, & Luz, 2023), particularly those with ID. The choice

between these two formats depends on the desired learning outcomes and factors such as resource availability, individual preferences, and the cognitive or social needs of the players (Sousa et al., 2023).

One of the key distinctions between analogue and digital games lies in their impact on peer interactions. While digital media can influence the quality of ongoing interactions, it does not necessarily foster subsequent prosocial behaviour. Research by Von Steinkeller and Grosse (2022) found that children tend to be more socially engaged when playing analogue games compared to digital ones. Specifically, children interact less frequently and have fewer verbal exchanges when engaging in cooperative digital games than in analogue counterparts. This suggests that digital games can provide immersive and engaging experiences but they may not promote the same level of cooperative behaviour as analogue games.

However, the influence of digital games on learning and cognitive enhancement is undeniable. Digital games can enhance cognitive engagement through highly personalised learning experiences, adaptive difficulty levels, and immediate feedback. Research has shown that well-designed digital games can improve problem-solving skills, memory, and attention, particularly when integrated into educational curricula (Reynaldo, Christian, Hosea, & Gunawan, 2021).

On the other hand, analogue games provide a tactile, real-world interaction that enhances spatial awareness, fine motor skills, and face-to-face communication. For instance, when comparing the digital and analogue versions of the Memory game, Nilsen, Lundin, Wallerstedt, and Pramling (2021) found that the experience differed significantly in terms of how players interacted with the game. Children, especially those who are more used to digital versions, may apply strategies from digital play when engaging with the physical game, indicating that the line between digital and analogue gaming is becoming increasingly blurred.

Given this context, this exploratory study aims to address the research question ‘How do digital and analogue games contribute to the cognitive, social, and emotional experiences of PwID in Portuguese institutions?’ (RQ1). In order to make it more objective, we have also listed a series of sub-questions:

- RQ2: How do support workers perceive the cognitive benefits of digital and analogue games for PwID?
- RQ3: What are the observed social interactions and behaviours of PwID when engaging with digital versus analogue games?
- RQ4: What challenges do support workers and PwID encounter in using digital and analogue games, and how are these addressed?

2. ADOPTED APPROACH

The methodology adopted in this study was divided into two key phases. The first phase focused on a participatory and inclusive design process, engaging PwID, support workers, and students to collaboratively develop games tailored to the needs and preferences of the target population. The second phase applied thematic analysis to assess the outcomes of this collaboration, ensuring the diverse representation of voices and experiences.

2.1. Phase One: Participatory and Inclusive Design

The development of games for PwID in this study emerged from a collaborative, participatory design approach involving specialised NGOs, scholars, and university students, driven by the professional experience and research background of one of the project’s researchers, alongside input from the community. The design process followed a structured,

iterative model where PwID and support staff were involved at key stages, to develop both analogue and digital games in response to the limited availability of suitable resources in the partner institutions. These games addressed the need for low-cost, durable, and reproducible materials, aiming to replace children's games with more appropriate themes for adult users with ID. Previous research mostly on the extensive catalogue of developed digital games highlights their potential to enhance empowerment, well-being, and inclusion (Sousa et al., 2022a), while also fostering inclusive attitudes among the students involved in their creation (Sousa, Neves, & Damásio, 2022b).

2.2. Phase Two: Thematic Analysis

Braun and Clarke's (2006) thematic analysis is a flexible, qualitative method for identifying, analysing, and reporting patterns – here called themes – within data. It is particularly well-suited to research with a participatory and inclusive focus, making it an ideal choice for the second phase of this study. In this phase, the collaboratively designed digital and analogue games were tested through interviews with support workers from community institutions supporting PwID. Thematic analysis was used to examine these interviews, allowing for a deep exploration of participants' experiences with the games. Therefore, it aligns with the study's inclusive-driven approach, as it prioritises the insights of those directly involved in PwID support, enabling a thorough understanding of the perceived impacts of the games, nuances and complexities of these experiences.

3. MATERIALS AND METHODS

3.1. Developed Games

The games developed in this context are a consequence of the participatory design adopted and the design methodology in partnership with social institutions and the community, previously researched by the authors (Sousa & Neves, 2023) and others such as Léste, Sousa, Farbiarz, Dias, and Farbiarz (2023). In addition, they obey the principles of economic accessibility, in addition to cognitive and/or motor accessibility, focusing on their dissemination in Open Access (OA) – through the OPERAT platform (<https://operat.ulusofona.pt>) – and low-cost reproducibility.

3.1.1. Jogo da Glória

Jogo da Glória (Figure 1) is a board game based on the traditional Goose game, where players roll dice to advance along a series of squares, aiming to reach the final square first. Some squares trigger special actions, like moving backwards or repeating turns. This version is designed for adults with ID, avoiding childish designs that often lead to rejection by this group. The rules have been simplified, and thematic content has been introduced to encourage cultural and informational engagement. Themes include basic geometric shapes, fast food items, professions, and famous landmarks. The game pieces are laser-cut for easy, low-cost, OA reproduction, and the game's layout and themes can be adapted based on players' interests, fostering group interaction and decision-making.

Figure 1.
Example of game session with Jogo da Glória. Photo by the authors.



3.1.2. Seasonal Dominoes

Seasonal Dominoes (Figure 2) are an adaptation of the traditional domino, where the quantity circles have been replaced by illustrations of winter and summer clothing and symbols. The Winter Domino has images associated with each season, such as a scarf, hat, umbrella, rubber boots, a puddle of water and a cloud with drops representing rain, while the Summer Domino has a swimsuit, T-shirt, shorts, sun hat, flip-flops and the sun. Each piece has 2 images and the list is combined to make 28 different pieces. As with *Jogo da Glória*, it was decided to avoid childish illustrations in order to keep the puzzles suitable for teenagers and adults. As far as the game dynamics is concerned, it is supposed to follow the model of traditional dominoes.

Figure 2.
Example of game session with Seasonal Dominoes. Photo by the authors.



3.1.3. Endless Runner

This game is a two-lane endless runner with a twist of humour, in which an older woman in a tracksuit runs through city, forest and beach scenes, holding an umbrella to protect an unfinished curly perm. The player controlling this unusual character will have to

avoid the various obstacles along the way by changing lanes or jumping, and pick up umbrellas to protect the old lady's hairstyle from the rain. If the character hits an obstacle or fails to pick up one an umbrellas before the 'umbrella bar' runs out, the character will return to the start of the course. Endless Runner has a free play option for training purposes and allows the speed of the character to be adjusted in order to adapt the gameplay to the reaction and motor skills of the player.

Figure 3.
Screenshot of Endless Runner. Image by the authors.



3.1.4. Futebolástico!

This is a maze-type videogame set on a football pitch (Figure 4), in which the aim is to get the ball to the goal along paths defined by elements of these imagery, starting with the traditional conical pins used in training, then moving on to players from two teams that gradually increase in number. The difficulty of the levels is determined by the increasing complexity of the paths, with no time limit and no possibility of conceding goals in order to keep the game as simple as possible.

The football imagery is reinforced by a fan waiting for the player to bring her a flower. This is not a mandatory challenge, but adds a thematic factor and complexity that can stimulate attention and motor coordination in people with difficulties in this domain.

Figure 4.
Screenshot of Futebolástico!. Image by the authors.



3.2. Participants and Interviews

The participants in this study – here considering only the Phase Two of the described approach – were nine professionals, referred to as "support workers" throughout the research, from two institutions in the field of disability located in the North of Portugal. These support workers participated in two group feedback interviews (one online and one written), guided by a semi-structured set of questions focused on the role of games in the daily lives and occupational activities of PwID. Their feedback was based on the use of the games with 36 PwID, who will be referred to as "users" or "clients" in this study, following the terminology used in the participating institutions.

4. RESULTS

4.1. Overall Impressions

In both institutions, the games were seen as having a positive impact on the players' well-being, promoting social interaction, healthy competition and cognitive stimulation (attention, memory and reasoning). *Seasonal Dominoes* helped train vocabulary, logical reasoning, attention, memory and visual perception, while also promoting interaction and tolerance of frustration. *Jogo da Glória*, although initially confusing due to the lack of guidance such as a rulebook, generated greater enthusiasm and moments of sharing after a few instructions.

In the second institution, analogue games were more popular with younger participants and those with motor difficulties. Digital games, such as *Futebolástico!*, were favoured by adults due to their simplicity and ease of use. These games were seen to increase the perception of maturity among players, as they are often associated with adult life, while analogue games sometimes carry a more childish connotation. Nonetheless, analogue games free of cartoonish elements, were well received by adults, highlighting the importance of avoiding infantilisation in content design.

4.2. Emerging Themes

The thematic analysis – developed according to the approach of Braun and Clark (2006) – of the two institutional feedbacks, obtained in the form of interviews, made it possible to identify six emerging themes, explaining the potential and constraints that arise from the use of games, both analogue and digital, in the daily lives of people with disabilities. These include: (1) cognitive skills development; (2) social interaction and competence; (3) accessibility and usability challenges; (4) perception and engagement with digital vs. analogue games; (5) need for personalisation and adaptation; and (6) technical challenges and improvements.

4.2.1. Cognitive Skills Development

Both digital and analogue games were perceived as valuable tools for stimulating cognitive processes such as attention, concentration, memory, and reasoning. For example, one of the professionals noted that the games promoted "attention and concentration, memory, and reasoning, planning and execution", especially with games like *Seasonal Dominoes*, which also contributed to vocabulary enrichment and logical reasoning. However, certain games were noted to be challenging due to the complex motor skills and planning required.

4.2.2. Social Interaction and Competence

The games were also seen as beneficial for fostering social interaction and collaboration. Games like *Jogo da Glória* and *Seasonal Dominoes* were particularly relevant in promoting healthy competition and peer interaction. One support worker shared that *Jogo da Glória* eventually became a source of social engagement, stating that it provided "satisfaction, enthusiasm, and moments of socialising and sharing between the PwID". However, in some cases, and in the same game, clients required one-on-one guidance, limiting group-based social interactions.

4.2.3. Accessibility and Usability Challenges

Support workers frequently raised concerns about the usability of certain games. *Jogo da Glória*, for example, was initially poorly received due to unclear instructions, as noted by a participant: "Initially, this game was not well received because there were no instructions, making it very confusing".

Customisation of game content emerged as a critical factor in ensuring the accessibility of the games. Support workers suggested that simpler and more relatable themes would better suit the cognitive levels of PwID. One participant proposed, "simpler themes like transport, fruits and vegetables, or animals would work better for our group of users". This insight highlights the importance of adapting game complexity to the abilities and needs of the players to facilitate engagement.

Moreover, some games posed motor challenges for clients with physical difficulties. For instance, the ones with smaller pieces were difficult for those with fine motor issues. One support worker suggested that adding pins to the pieces would improve accessibility for those players: "For users who have more difficulty with motor skills, the pieces could have pins".

4.2.4. Perception and Engagement with Digital vs. Analogue Games

Digital games were particularly well-received by adult clients, who associated them with maturity and a sense of independence. One support worker explained, "I think the videogames are more impactful...because it's on a computer, it's not something infantilised like a box". Digital games, such as *Futebolástico!*, were noted as favourites.

Analogue games, while appreciated for their tactile nature, were sometimes seen as childish by older clients. However, when the design avoided cartoonish elements, these games could be appealing to a broader audience.

4.2.5. Need for Personalisation and Adaptation

Customisation was a recurring theme throughout the interviews. Support stressed the need to tailor games to meet the varying cognitive and motor abilities of clients. This included the need for visual aids to help PwID understand game mechanics as a key finding.

Flexibility in how games were played was highlighted as a factor in promoting engagement and creativity. One participant described how a client turned the *Jogo da Glória* into a free play session: "He wanted to make a racetrack for cars to play with; it was very funny".

4.2.6. Technical Challenges and Improvements

While digital games were popular, some technical issues, such as software bugs, impacted their usability. For example, one participant reported, "The *Endless Runner* game freezes when moving to another level", indicating a need for further testing and optimisation of the digital games used. Aligned with this, several recommendations were made to improve the design of both digital and analogue games.

5. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The findings from this study provide relevant insights into the impact of digital and analogue games on the cognitive, social, and emotional experiences of PwID in Portuguese institutions, exploring their daily and occupational relationship with both digital and analogue games.

Regarding RQ1, the study found that both types of games have significant potential to enhance well-being, stimulate cognitive processes, and foster social interaction among PwID. Games like *Seasonal Dominoes* were specifically noted for fostering cognitive skills such as attention, memory, and logical reasoning. Support workers highlighted the ability of these games to create structured learning opportunities, which align with the existing literature on the cognitive benefits of game-based learning (Sousa et al., 2022a; Terras et al., 2018).

In response to RQ2, support workers perceived both digital and analogue games as feasible tools for cognitive stimulation. Digital games were associated with the ability to personalise learning experiences and adapt gameplay to the player's cognitive needs. For example, *Endless Runner* and *Futebolástico!* were noted for providing immediate feedback and allowing adjustable difficulty levels. These findings are consistent with existing research indicating the role of digital games in enhancing problem-solving and memory (Reynaldo et al., 2021). However, games requiring more advanced and/or fine motor skills posed challenges for players, highlighting the need for accessible game design.

Regarding the observed social interactions and behaviours of PwID when engaging with digital versus analogue games (RQ3), support workers observed that analogue games, such as *Jogo da Glória*, fostered more frequent social interaction and peer collaboration compared to digital games. However, they also reported that digital games offered a sense of autonomy and maturity, particularly for older adults. This aligns with findings by Von Steinkeller and Grosse (2022), who noted that analogue games tend to encourage richer verbal exchanges and cooperation, while digital games may offer more individualised experiences.

The challenges encountered by support workers and PwID in using digital and analogue games (RQ4) were addressed by several key observations related to usability and accessibility. The absence of clear instructions for some games, particularly *Jogo da Glória*, initially led to confusion among players. Additionally, games with small or intricate components posed difficulties for clients with motor disabilities. Recommendations from support workers to include visual aids, simplified themes, or physical modifications (e.g., adding pins to pieces) reflect the need to design games that account for both cognitive and motor challenges – the so-called intersectional accessibility (Heron, Belford, Reid, & Crabb, 2018).

Overall, the study suggests that both digital and analogue games can play a valuable role in the daily lives of PwID, offering opportunities for cognitive development, social engagement, and emotional well-being. However, the findings also highlight the importance of customisation, accessibility, and flexibility in game design to meet their diverse needs.

Future studies should involve a larger sample across multiple institutions to enhance the generalisability of the results. Including direct feedback from PwID would provide a more comprehensive understanding of their experiences with both digital and analogue games. Additionally, future research could investigate the long-term cognitive and social effects of gaming on PwID, particularly how consistent use influences their overall development. Finally, further exploration of customisation and adaptive game design is necessary, focusing on creating games that are both engaging and suitably challenging for individuals with varying cognitive and motor abilities.

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Chapter # 23

ECODESIGN AS AN INNOVATIVE APPROACH TO TEACHING IN SECONDARY SCHOOLS

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ABSTRACT

The main objective of this chapter is to provide a new tool for teaching technical subjects in secondary schools. Specifically, it is ecodesign as a systematic process of designing and developing a product, which, in addition to features such as functionality, safety, technical feasibility, etc., places great emphasis on achieving a minimal negative impact of the product on the environment, mainly from the point of view of the life cycle. The introduction to the chapter describes the product manufacturing process as a system that is managed with respect to the environment. The next part of the chapter summarises the theory on the integration of environmental aspects into the product design process using the ecodesign methodology. In conclusion, the chapter compares metal and plastic 3D printed products and considers the usual requirements for product properties such as functionality, quality, safety, price and appearance. The connection of ecodesign and environmental management systems is an effective implementation of a preventive approach to the identification of risks of products, activities and services and the subsequent setting of preventive measures, which will clearly show the students the importance of Ecodesign as a tool.

Keywords: ecodesign, sustainable development, life cycle assessment, recycling, 3D print.

1. INTRODUCTION

Text Environmental education aims to lead to responsible behaviour towards the environment, living organisms, other people, and oneself. The key question is how to approach the teaching of sustainable development in schools and how to familiarise pupils with the topic. Here, we can encounter several problematic points. The first problem point may be the student's initial knowledge. It can be assumed that students have already heard about the theory of sustainable development and environmental management, but the constant question remains how extensive and deep the knowledge is. Another problem is the implementation of the theory of sustainable development and environmental management into study programs because sustainable development has an interdisciplinary character, and therefore, we must work simultaneously in areas such as economic, environmental, social, and cultural. Therefore, the main goal of the article is to provide a new way of teaching technical subjects in secondary schools. Specifically, ecodesign as a process of designing, optimizing, or developing products is being addressed, for example, by the Mexican Ministry of Education by introducing a new educational model/programme focused on developing students' competencies in this area. This led to the need to analyze and reevaluate the current content of teaching on environmental issues, and as a result, it turned out that ecodesign is a suitable method for developing the educational process in engineering and other technical fields, because it allows students to connect knowledge with the areas of ecology and technology (Bravo-Díaz & Gutiérrez-Yurrita, 2015).

Furthermore, in France, since 2011, they have focused on integrating ecodesign into technological education in secondary schools, which includes managing technological projects with a view to sustainable development, but although students acquire technical knowledge about ecodesign, they often lack a broader understanding of economic, social and ethical aspects, which leads to a superficial approach to sustainable development (Perpignan, Robin & Girard, 2017). The research (Perpignan, Robin, Baouch & Eynard, 2020) described by the authors focused on the French education system from secondary school to university to examine the integration of sustainability and ecodesign in different technological curricula and practices. The aim was to estimate the actual place of sustainable development and ecodesign in technological education courses. Although concepts, knowledge and skills related to ecodesign appeared in many different programs, the study highlighted that there was no continuity between primary school, secondary school and university. As a result, teachers had difficulty understanding the objectives and coherence of the program and students were not very comfortable with the issues of sustainability and ecodesign. The authors (Perpignan et al., 2020) suggested improving programs and practices by developing multidisciplinary curricula that cover most sustainable topics and integrate best practices from international universities.

In Ireland, the research team (McGarr & Lynch, 2021) set out to analyse the technology education curricula for lower secondary education to examine how they responded to sustainability issues. Sustainability and the environment were mentioned across the subjects examined, but they appeared to be very narrowly focused, focusing on material choice and energy consumption in the design process. A one-way relationship between technology and society was presented, which failed to recognise the societal influence on the development of technology. Furthermore, sustainability was not conceptually defined in any of the syllabi. In examining possible reasons for this token recognition within the curricular response, potential reasons were explored, including resistance to curriculum change, partial denial of the scale of the challenge, ignorance of current unsustainable practices within subjects and a lack of understanding of how to respond adequately to the challenge. Perspectives from a wider range of stakeholders are needed to overcome this narrow thinking. This should particularly include the perspectives of those who will be most affected by the environmental sustainability crisis we now face, namely young people.

Ecodesign can be integrated into educational programs and used in specific examples when teaching technical subjects in secondary schools. Students can compare two products, where one product will be manufactured according to ecodesign rules and the other product will be manufactured in a conventional way and then analyze their impact on the environment, including economic analyses. Ecodesign contributes to the development of students' skills in the field of sustainability, critical thinking, and technical creativity by teaching them to minimize the negative environmental impacts of products, analyze the life cycle of products, and look for innovative solutions. Teachers can integrate ecodesign into their curricula through project-based learning, case studies, and practical exercises, which provide students with practical skills relevant to the current job market. Ecodesign can be integrated into school curricula as part of technical and science subjects, helping students develop the skills needed to solve environmental problems and supporting interdisciplinary learning. Visits to industrial production plants are an important part of teaching in secondary vocational schools with a technical focus, because students can see production processes in practice. Also, the practice of secondary vocational school students in industrial plants allows students to gain practical experience and connect theoretical knowledge acquired at school. Getting acquainted with production processes and especially meeting with experts from practice is an invaluable opportunity for students, which will allow them to better prepare for a future career in technical fields, and that is why part of this article is dedicated to industrial plants and production processes.

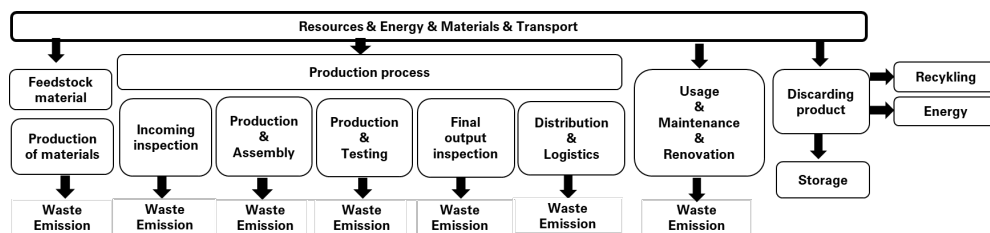
2. LIFE CYCLE ASSESSMENT OF A PRODUCT

In the following part, the teaching of the issue of sustainable development is demonstrated in the example of a comprehensive view of the general scheme of the production process, which is based on the concept of the product life cycle (Figure 1). This cycle does not start with production, but already at the stage of obtaining raw materials and materials. It continues with their transport, input control, processing in production, output control and subsequent packaging, selected transport and distribution of the final or semi-finished product. The life cycle continues with the preventive maintenance phase. In most cases, the life cycle ends with the disposal of the product at the end of its useful life.

For most products, environmental aspects and impacts occur at all life cycle stages. Inputs and outputs at each stage of the product's life cycle are key to assessing these environmental impacts (Figure 2).

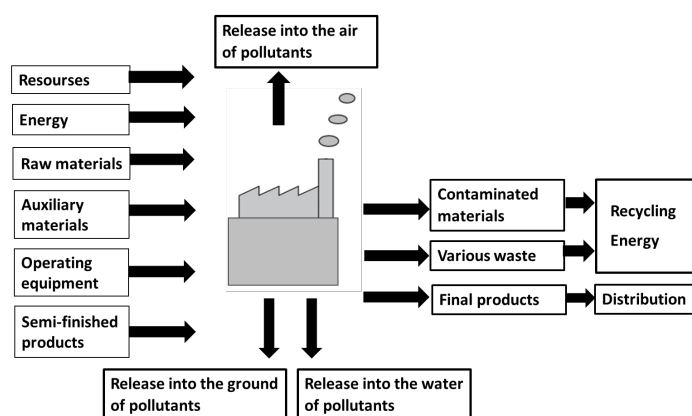
An educator who uses the goals of global education and a comprehensive view of the general scheme of the production process, based on the concept of the product life cycle (Figure 1 and Figure 2), and uses active learning methods (e.g. project and situational learning, experiential pedagogy, engaged learning), can put together a sustainable development lesson plan.

Figure 1.
General scheme of the production process, which is based on the concept of the life cycle of the product.



It is important that high school students understand the production process (Figure 1) and the general scheme of a manufacturing plant (Figure 2). It is important that the student is able to explain the production and life cycle of a product. Furthermore, he/she should be able to characterize the properties of the material suitable for production, and its subsequent disposal and the costs associated with it.

Figure 2.
General scheme of inputs and outputs of an industrial company.



Taking into account the entire life cycle of a product allows students to obtain the following interesting information: students will learn about the various raw materials and materials that are need for the production of a product, and understand their origin, availability and the environmental impact of their extraction and processing. The next part of the article focuses on the specific benefits of knowledge of the entire product life cycle for students and this knowledge will allow them to understand better the relationships between the production, use, and subsequent disposal of products, which is very important for sustainable development:

- i. knowledge of all the key properties of the product, students will learn to recognize how these properties can affect its functionality, durability, and sustainability, including the composition of materials, energy consumption in production, and recycling options;
- ii. knowledge of individual steps and processes of production allows students to gain a detailed overview of the separate stages of the production process, from the acquisition of raw materials to the production of the final product and its subsequent distribution, including an understanding of technological procedures, quality control rules, and logistical planning;
- iii. auxiliary materials are important in achieving product quality within individual production processes and therefore it should be important for educators to convey this knowledge to students and emphasize the role they play in the entire life cycle of a product and how they can affect emissions, water consumption and/or waste production;
- iv. understanding the product life cycle and its connection to the manufacturing process will help students gain knowledge about how the product is used in practice and how it interacts with other systems, and it is important to introduce students to maintenance management and the possibilities of reuse or recycling;

- v. identifying possible adverse environmental impacts can teach students to evaluate the potential negative environmental impacts of a product during its life cycle, analyze the ecological footprint, and evaluate long-term environmental risks.

3. ECODESIGN – CONCEPT, GOAL, IMPLEMENTATION

Ecodesign can be defined as a comprehensive concept of designing and developing products with the aim of reducing the number of negative impacts on the environment during the entire life cycle. By considering the environmental aspects of the products in addition to their standard properties such as functionality, durability, aesthetics, quality, safety, economy and ergonomics from the initial design phase, this approach aims to minimise the negative effects of products on the environment in the future (Pigosso, Zanette, Filho, Ometto, & Rozenfeld, 2010; Bertini, Buehler, Halbheer, & Lehmann, 2022).

The goal of the ecodesign concept is to reduce the product's negative impact on the environment in terms of its entire life cycle. It is important for students to realise that the main purpose of ecodesign is to find successful innovative solutions while simultaneously reducing the negative environmental effects of products. In this context, however, it is important to draw students' attention to the fact that ecodesign is not only an approach emphasising environmental issues in product designs, but also strives to introduce a global concept of the environment, which should ensure a systematic and comprehensive assessment of environmental impacts.

Ecodesign is a concept based on the principle of prevention, as it defines, based on analysis, the possibility of reducing potential adverse effects of the product even before its production. This principle is very important in the field of environmental standards and law, as environmental damage is often irreparable (Damohorský et al., 2010; Bundgaard & Huulgaard, 2023).

The use of concrete examples by the teacher in teaching is essential to explain to students that the inclusion of hazardous and harmful substances in the production of a product can make subsequent recycling processes impossible. For example, a plastic bottle that contains toxic additives can contaminate the entire recycling process during recycling, which means that this recycled product is dangerous and unusable for the production of new products.

On the contrary, it is equally important to show students a positive example of the use of ecodesign, for example, if a product is produced without the use of hazardous and harmful substances, this can have immediate positive effects in two key stages of its life: the product can be used without posing health risks to consumers and the material can be safely recycled at the end of its life cycle, allowing it to be reused for the production of new products. An interesting and practical example is the design of electronics. Another example that will be close to students is the production of a smartphone made of high-quality and non-toxic materials, ensuring not only the safety of users during use, but also facilitating the problem-free recycling of its components (metals and plastics), which protects human health, supports sustainable development.

Critical thinking and creativity can also be influenced by the application of eco-design to educational programs at secondary technical schools, and all this can lead to a deeper understanding of the importance of environmental responsibility and sustainable development.

For a better presentation of the product life cycle to students, it is appropriate to divide the product life cycle into distinct stages (see Table 1). The first phase is the concept and requirements definition, which involves defining requirements based on market research, customer needs and regulatory standards (quality, reliability, durability, safety). The next is the design and development phase, which is the phase where the product is conceived and developed, which includes product design, selection of suitable materials, creation of initial production documentation, subsequent production of prototypes, conducting initial tests and marketing activities. The main phase of the product life cycle is production, which includes serial production according to pre-approved documentation, obtaining materials from suppliers, conducting incoming material inspections, various tests, setting rules for final output inspection, issuing certificates of conformity and delivering products to the customer. During the operation phase, which is mainly focused on maintenance and system setup activities, which ensure safe and trouble-free operation of machines and equipment. The last phase of the product life cycle is disposal, which includes sorting, disposal, disassembly, recycling of the product and possible use in new products.

The knowledge and skills of educators were defined for the individual stages of the product life cycle. For the students to be involved in the discussion, basic requirements for the student's knowledge were assigned for each stage of the product life cycle.

Table 1.
Educator's competency matrix for the presentation of the product life cycle to students.

Stage Nr.:	Ecodesign process	Knowledge and skills of a teacher	Requirements for student knowledge	Newly acquired knowledge and experience
1.	conception and determination of requirements: the definition of requirements for quality; reliability; service life; safety; price	orientation in the standards and requirements of customers from various industrial sectors; knowledge of quality management financial analysis;	knowledge of the division of industry and its history; awareness of the role of work in our lives;	connecting the necessary knowledge from the field of quality to specific industrial sectors; basic knowledge of reliability theory;
2.	design and development: product design; material selection; creation of production documentation; marketing;	knowledge of 3D modelling; knowledge of the basis of marketing and its role in product development; prototype production;	knowledge of the structure and physical properties of substances; basics of technical drawing;	connecting the knowledge of the material engineering with technical documentation; knowledge of the role of prototype production;

Stage Nr.:	Ecodesign process	Knowledge and skills of a teacher	Requirements for student knowledge	Newly acquired knowledge and experience
3	production phase: serial production; delivery of materials from suppliers; inspection and delivery of the final product to the customer;	knowledge of the importance of quality control of incoming material and final product in relation to the environment; overview of audit types;	knowledge of the classification of industries;	overview of the activities of production and non-production processes in a production company; knowledge of the setting production process;
4	operation and maintenance;	knowledge of the type of maintenance; basic maintenance rules; knowledge rationalization;	types of machines and equipment in households and industrial companies;	knowledge of role of diagnostics and preventive maintenance;
5	disposal of the products: decommissioning; disassembly; recycling;	differences in the recycling of plastics, metal and other materials; carbon footprint;	knowledge of basic waste sorting rules;	knowledge of sustainable development goals and ecodesign;

4. 3D PRINTING TECHNOLOGIES AND DEVELOPING CREATIVITY

This part of the article is devoted to the 3D printing process, which begins with the design and continues with modeling, which is the process of creating a digital version of the future print. Another important step is the control and preparation of the material (e.g. filaments, fibers, powders, liquids, composites) depending on the type of 3D printer, and then follows the gradual application of layers of material according to the previously created model, and the result is the final product. After the 3D printing itself, it is very often necessary to finish the product and the finishing operations include both the assembly of the print itself and surface treatments to improve the quality of the product, for example, removing support structures, smoothing the surface, improving aesthetic properties or other treatments, and finally, a final quality control is performed to ensure that the final product is manufactured according to the drawing documentation and model and also meets all required specifications.

Within mechanical engineering, 3D printing is widely used for the production of prototypes, which significantly increase flexibility in the testing phase of developing new designs. 3D printing can also be used for small-scale production.

Casting, forging, machining, pressing and extrusion are some of the traditional, classic manufacturing methods that also start with design and modeling, but the material is prepared in a different form of suitable semi-finished products. As for production, it is carried out using different methods: casting involves pouring molten material into a mold, forging uses compressive forces to shape the material, machining involves removing material using

cutting tools, pressing shapes the material using presses and extrusion pushes the material through templates. Also, in the case of traditional production, subsequent heat treatment or surface treatment is performed and the final product is then subjected to final quality control.

If we compare these two manufacturing methods or technologies, several key differences can be revealed. Design flexibility, complex and detailed models that would be very difficult to achieve with classical methods are among the priorities of 3D printing. The advantages of traditional methods include that they can process a wider range of materials and are more proven in industrial, mass production (Krotký, Honzík & Moc, 2016; Böhm et al., 2023). Traditional methods are also associated with various rights and obligations in relation to the environment, waste management and assessment of environmental aspects (Tomaskova & Bicova, 2021; Tomaskova & Bicova, 2022; Zhichao, Qihong, Zhang & Tao, 2016; Al Rashid, & Koç, 2023). Some differences in the processes of 3D printing and standard production are listed in Table 2.

Table 2.
Differences in the processes of 3D printing and standard production.

Topic	Standard production	3D printing
Production method	Subtractive; Formative;	Additive
Production process	a) Transformation; b) Control quality; c) Transport & Storage;	a) Transformation; b) Control quality;
Production cycle time	Longer	Shorter
Materials according to production technology	Metals: Plate, Block, etc.; Plastics: Granulate;	Metals: Powder; Plastics: Filament, Tapes, Liquid Photopolymer;
Efficiency	Lower	Higher
Waste	Larger	Smaller
Human Recourses	Higher the number of various specialists	Deep knowledge of specific specialists
Life cycle	Longer	Shorter
Finance & Cost	Lower	Higher

Safety is always paramount in the production of a product, whether it is traditional manufacturing or 3D printing, and this means ensuring that the materials used for production are non-toxic and suitable for a specific application. The product must always reliably and effectively fulfill its intended function, which means that it is another critical aspect and this includes careful consideration of the materials used and their properties, such as strength, flexibility and durability, etc. Setting up a quality control process for products manufactured using 3D printing is necessary to verify that the product meets the required specifications and standards.

3D printing has also found its application in education, where it serves teachers and students in various forms, for example, statements from 3D printers can be used in schools and in many cases, printing yourself is cheaper than buying products on the market. Another benefit of 3D printers is that it allows students to actively create their own models and observe the production. The use of the models themselves created during 3D printing lessons extends to almost all subjects taught in elementary school, for example, physical models, or other teaching aids and interactive educational games.

5. CONCLUSION

In environmental education, it is important to pay attention to the connection between seemingly disparate topics and to explain these connections even in distant areas. More and more secondary schools are currently following the trend of introducing 3D modeling into their teaching. This area is receiving increasing attention, partly because secondary schools are purchasing 3D printers for educational purposes. Since teaching 3D modeling and 3D printing seems to be a very current topic, this area should be given attention at the level of subject didactic theory in technical subjects. Integrating 3D modeling and 3D printing into secondary education not only improves technical skills but also provides a platform for interdisciplinary learning. Students can examine the environmental impact of their designs in terms of factors such as material selection, energy consumption and waste generation.

Implementing ecodesign into educational programs will help students better understand the importance of an ecological approach and sustainable development. In this way, students can not only gain theoretical knowledge, but also practical experience in the field of technical design and environmental responsibility.

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Chapter # 24

ONLINE EDUCATION IN LATIN AMERICAN HIGHER EDUCATION: A SYSTEMATIC REVIEW

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ABSTRACT

COVID-19 forced higher education institutions to implement virtual education activities without being prepared for it, representing a challenge for the traditional model. This has been exacerbated in Latin American institutions, as they do not have adequate resources and infrastructure. The objective of the study was to identify trends in online education research in Latin America because of the health emergency. To achieve the objective, a systematic literature review was carried out. Documents published in Scopus between 2008-2023 were analyzed using the Biblioshiny and VOSviewer software. 47 documents were found, of which 40 were published in the period 2019-2023. Keywords were analyzed according to their co-occurrence. 376 documents were found and 47 with a minimum of two co-occurrences were selected. The documents have been associated in four clusters. The results show the impact on university education during and after the pandemic in Latin America. Online education has continued after the pandemic, exploring new forms of learning. It has enabled access to higher education for sectors of the population that traditionally could not join it, due to issues such as geography and economics. Challenges are noted in creating infrastructures and processes that allow promoting this type of teaching.

Keywords: online education, virtual education, e-learning, Covid-19, Latin America, systematic review of the literature.

1. INTRODUCTION

Universities experienced an unprecedented shift from traditional face-to-face teaching and learning to online learning in response to the COVID-19 lockdown (Marinoni, Van't Land, & Jensen, 2020). The educational institutions especially in developed economies, resorted to virtual education implemented via digital learning platforms and technologies including Teams, Zoom, social media, and cloud technologies to offer virtual learning environments (VLEs) for academic teaching (Akpan, Offodile, Akpanobong, & Kobara, 2024). Particularly, many universities in Latin America are experiencing a serious lack of resources that has plunged them into a deep financial crisis and the COVID-19 pandemic has increased this calamity (Quispe-Prieto, Cavalcanti-Bandos, Caipa-Ramos, Paucar-Caceres, & Rojas-Jiménez, 2021). According to UNESCO, on April 1, 2020, schools and higher education institutions (HEIs) were closed in 185 countries, affecting 1,542,412,000 students, constituting 89.4% of total enrolled students (Bárcena & Uribe, 2020). Of them, more than 160 million were students from Latin America and the Caribbean (Bárcena & Uribe, 2020). The authorities of educational institutions initiated online learning strategies through virtual online learning environments, which has been called "emergency

remote teaching” (Barbour et al., 2020), and has been defined as “a temporary change of teaching to an alternative mode of remote teaching due to crisis circumstances” (Iglesias-Pradas, Hernández-García, Chaparro-Peláez, & Prieto, 2021). Although many higher education institutions already had virtual learning environments, which were used for face-to-face teaching, the challenge for teachers was to provide adequate teaching materials through e-learning tools that kept students highly engaged (Tadesse & Muluye, 2020). On the other hand, students also faced obstacles of the digital divide to access technology and relevant digital tools, considerably affecting learning. Access to the Internet and optimal electronic devices are just some of the challenges they faced (Litchfield, Shukla, & Greenfield, 2021). In Mexico, various phases of social confinement were announced and the institutional program “Learn at Home” was presented, highlighting deficiencies in Mexican homes, given the conditions of poverty in rural and indigenous areas, overcrowding in marginal neighborhoods in urban areas and the infrastructure in residential areas where not all the academic community has optimal conditions of access, availability, digitalization and technological literacy (López & Medina, 2021).

2. BACKGROUND

Universities have undergone a radical change in the teaching process, moving from a traditional face-to-face environment to emergency remote teaching (ERT), that is, a temporary change of instruction due to crisis circumstances (León-Cázares, Becerra-Peña, Moreno-Arellano, & Borrayo-Rodríguez, 2024). Universities increased the use of digital tools and virtual platforms not only for distance education students but also for face-to-face students (Salas-Pilco, Yang, & Zhang, 2022). However, and despite the promptness with which online education mechanisms were implemented in educational institutions, this presented some important benefits such as, for example, the development and realization of activities related to collaboration, communication and the search for information (Knopf, Stumpp, & Michelis, 2021). Motivation in the educational field is of utmost importance as it influences the teaching-learning process (Vilchez Tornero & Siguenza Campoverde, 2023). Academic motivation is the basic determinant of academic performance and is revealed as one of the best predictors of students' school adaptation (Medina Ruiz, Mera Mendoza, Montoya Zamora, Ruiz Tuarez, & Zambrano Mera, 2023). It is a process that activates, directs, and above all perseveres in a behavior to achieve a certain objective (Cahuana Cuti, Mamani-Benito, & Carranza Esteban, 2020).

The COVID-19 pandemic brought about sudden changes in learning styles and environments, affecting pedagogical practices. The rapid transition from face-to-face to virtual education during periods of isolation, presented numerous challenges. These challenges included emotional adjustments, cognitive demands, exhaustion, strained student-teacher relationships, difficulties in organizing independent work and maintaining focus, and exacerbation of inequalities due to limited access to technology or digital divides (Garzon, Villamil Duarte, Velasco Forero, & Herrera Jacobo, 2024). Today's students have been impacted by their external environment requiring them to navigate a volatile and uncertain teaching and learning environment. The critical dialogic shifts in teaching and learning have created unique opportunities to think differently about the assumptions and processes that have become the norm for interaction between teachers and students on LMS platforms. The abrupt shift to remote learning in higher education institutions should allow for differentiation, but it has also precipitated a dialogic, critical and deliberative relationship of attention, as well as an ethic of care, in online teaching and the learning process involving

student and teacher (Pietersen, 2022). It has also brought us many challenges, such as guiding the route for the introduction of smart technologies that ensure the continuity of education. This wave of digital transformation brings long-term benefits and goes beyond the mere growth of distance learning. Online education opportunities, open educational resources, and other technologies can increase academic productivity. The above aspects could accelerate the pace of learning and reduce costs (Fernandez-Batanero, Montenegro-Rueda, Fernández-Cerero, & Tadeu, 2022).

As knowledge becomes a significant factor of inequality, the modern information society imposes new requirements on the institution of education. Now, the role of physical labor is reduced and the importance of intellectual labor increases, consequently increasing the importance of education. Education is updated to respond to the challenges of modern society. Although the objectives remain the same, the tools and techniques for the teaching-learning process are changing. An example of this is the rise of the implementation of online learning platforms, particularly in higher education (Begicheva, Beregovskaya, & Grishaeva, 2019). However, the causes and manifestations of the digital divide in higher education are related to the infrastructure, digital training for students and teachers, and access to technological resources. Highlighting the influence of socioeconomic and cultural contexts that impact the equitable distribution of the components of virtual education (González Ciriaco, 2024).

3. METHODS

3.1. Design

To achieve the stated research objective, a Systematic Literature Review (RSL) was carried out, which is a quantitative analysis of the documents published in an area of science and an adaptation of that proposed by Tranfield (Kraus et al., 2022; Tranfield, Denyer, & Smart, 2003).

3.2. Objectives

The objective of the study was to identify trends in research on online education in Latin America in the wake of the COVID-19 pandemic.

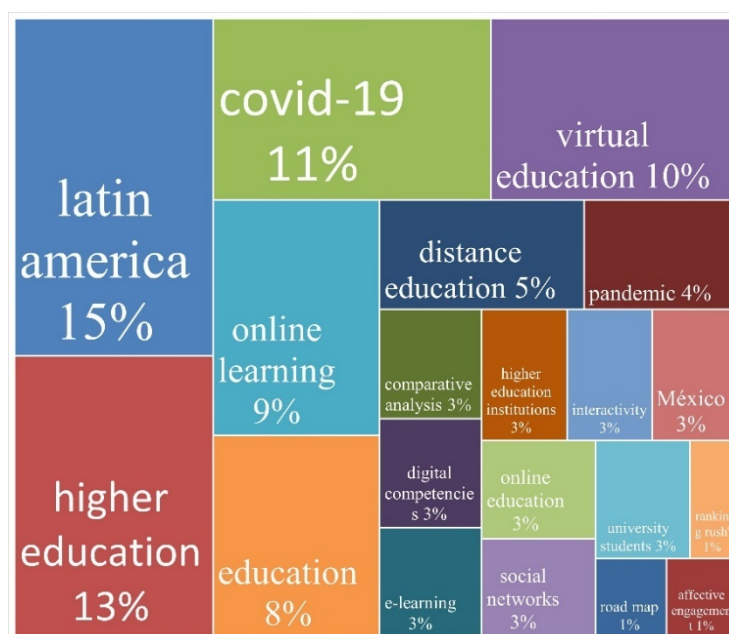
3.3. Methods

The period 2008-2023 was analyzed. The search was carried out in the Elsevier Scopus database, due to the quality of the documents it houses (Espinoza-Torres & Segarra-Oña, 2022). The review was limited to articles, review articles and book chapters already published. 47 documents were found that met the stated requirements. The Biblioshiny and VosWier programs were used to analyze the collected documents. The search term was: ((TITLE-ABS-KEY (“online learning”) OR TITLE-ABS-KEY (elearning) OR TITLE-ABS-KEY (“virtual education”) AND TITLE-ABS-KEY (“latin america”) OR TITLE-ABS-KEY (latam)) AND (LIMIT-TO (DOCTYPE, “ar”) OR LIMIT-TO (DOCTYPE, “re”) OR LIMIT-TO (DOCTYPE, “ch”)) AND (LIMIT -TO (PUBSTAGE, “end”)).

4. RESULTS

Forty-seven documents have been found, of which 40 were published in the period 2019-2023. When analyzing the 20 keywords most used by the authors, “Covid-19” stands out with 11.0% (Figure 1). This indicates the transformation that the pandemic had in online education, forcing teaching to be transformed due to the restrictions generated. Likewise, the keyword “digital competences” emerges as a variable to consider. This is manifested in the evolution that both teachers and students must have for adequate virtual education.

*Figure 1.
Word cloud.*



The most relevant article according to the total number of citations is the one prepared by Salas-Pilco et al. (2022), with a total of 109 citations (Table 1). This is despite being the most recent document in this analysis. The commitment of university students, as well as their motivation with online education, are priority approaches in research. The second most cited document is the one prepared by Friedrichsdorf et al., (2019), with 39 citations. This one, together with the one prepared by Chary and Rohloff (2014), are in the area of medicine, showing the relevance of online education in this area.

Table 1.
Most cited documents.

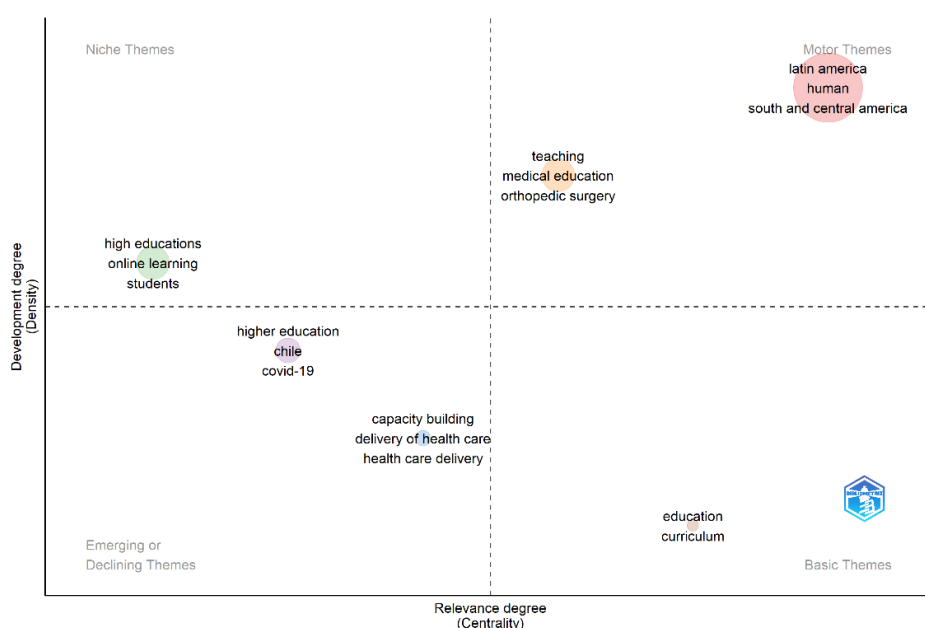
Autor	Document	Journal	Year	Total Citations
Salas-Pilco S.Z.; Yang Y.; Zhang Z.	Student engagement in online learning in Latin American higher education during the COVID-19 pandemic: A systematic review	British Journal of Educational Technology	2022	109
Friedrichsdorf S.J.; Remke S.; Hauser J.; Foster L.; Postier A.; Kolste A.; Wolfe J.SJ,	Development of a Pediatric Palliative Care Curriculum and Dissemination Model: Education in Palliative and End-of-Life Care (EPEC) Pediatrics	Journal of Pain and Symptom Management	2019	39
Sekli G.F.M.; De La Vega I.	Adoption of big data analytics and its impact on organizational performance in higher education mediated by knowledge management	Journal of Open Innovation: Technology, Market, and Complexity	2021	24
Chary A.N.; Rohloff P.J.	Major challenges to scale up of visual inspection-based cervical cancer prevention programs: The experience of Guatemalan NGOs	Global Health Science and Practice	2014	21
Quispe-Prieto S.; Cavalcanti-Bandos M.F.; Caipa-Ramos M.; Paucar-Caceres A.; Rojas-Jiménez H.H.	A systemic framework to evaluate student satisfaction in Latin American universities under the covid-19 pandemic	Systems	2021	18
Suárez L.M.C.; Núñez-Valdés K.; Alpera S.Q.Y.	A systemic perspective for understanding digital transformation in higher education: Overview and subregional context in Latin America as evidence	Sustainability	2021	15
Soria-Barreto K.; Ruiz-Campo S.; Al-Adwan A.S.; Zuniga-Jara S.	University students intention to continue using online learning tools and technologies: An international comparison	Sustainability	2021	13
Medina-Guillen L.F.; Quintanilla-Ferrufino G.J.; Palma-Vallejo M.; Guillen M.F.M.	Workload in a group of Latin American teachers during the covid-19 pandemic	AERA Open	2021	12
Cellini S.R.; Grueso H.	Student Learning in Online College Programs	AERA Open	2021	12
Scagnoli N.	A review of online learning and its evolution in latin America	Policy Futures in Education	2009	11

It is the Sustainability journal, based in Switzerland, where researchers prefer to publish their research with a total of 4 (Table 2). There are three journals in the United Kingdom, followed by the United States. The journal Ciencia da Informacao, based in Brazil, with an interdisciplinary focus, is the only journal based in Latin America that published a relevant article. Although the journal Academia Revista Latinoamericana de Administracion seems to be based in Latin America, it is published by the publisher Emerald Publishing, based in the United Kingdom.

Table 2.
Most relevant sources.

Sources	Country	Articles
Sustainability	Suiza	4
Academia Revista Latinoamericana De Administracion	United Kingdom	1
Aera Open	United States	1
Bmc Women's Health	United Kingdom	1
British Journal of Educational Technology	United Kingdom	1
Cancer Epidemiology	Netherlands	1
Ciencia da Informacao	Brazil	1
Croatian Journal of Education	Croatia	1
Developments in Marketing Science: Proceedings of the Academy of Marketing Science	United States	1
Digital Education Review	Spain	1

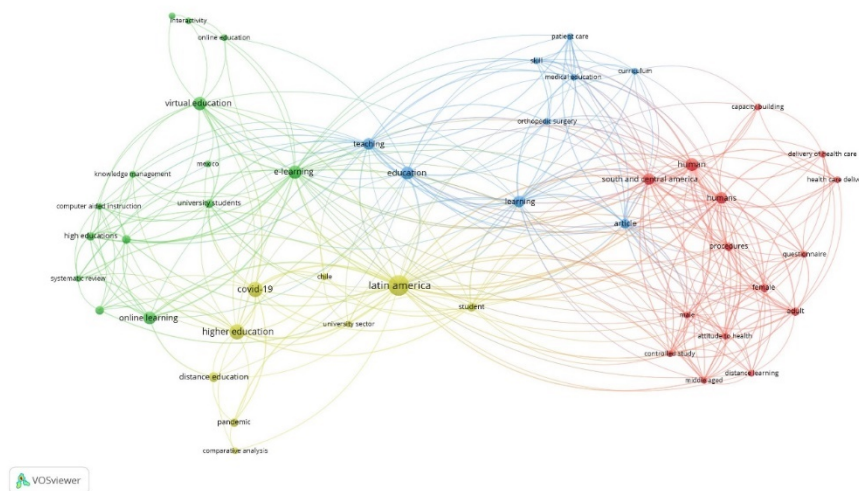
Figure 2.
Thematic map.



The thematic map shows us the degree of relevance of the keywords according to their degree of development, expressing it in a matrix with four quadrants (Figure 2). The driving keywords are Latin America, Human and South and Central America. This shows congruence with those implemented in the search engine. The basic themes in the analyzed research are education and curriculum. This is also in line with the research being focused on university education. The emerging themes are capacity building and health care delivery, which show the areas of research that can set the tone for the future.

The co-occurrence analysis of the author's keywords was performed with at least two co-occurrences (Figure 2). A total of 47 keywords resulted from the analysis, which were grouped into 4 clusters.

Figure 3.
Formation of keywords in clusters.



5. DISCUSSION

In the first cluster, keywords focused on people's health are identified, such as “attitude to health”, “delivery of health care”, “health care delivery”; as well as “human”, “humans”, “female” and “male”. The online education implemented during the pandemic had the main purpose of caring for people, leaving education itself as a secondary objective (Chary & Rohloff, 2014; Feliu et al., 2023; Friedrichsdorf et al., 2019; Hughes, Ferreira De Azeredo-Da-Silva, & Hincapie, 2019; Lewandrowski et al., 2023; Reyna et al., 2022).

The second cluster grouped together the keywords referring to online education, such as “e-learning”, “online education”, “online learning” and “virtual education”. Virtual education explains the variety of teaching or learning formats where the instructors collaborate or interface with learners through electronically mediated platforms (Akpan et al., 2024), otherwise known Learning Management System (LMS). These words were in conjunction with those focused on university education, “high educations”, “higher education institution” and “university students”. Research on online education has focused mainly on university education, due to the virtual modalities that higher education institutions have

carried out to incorporate students who cannot access traditional education (Almaraz-Rivera, 2023; Falavigna et al., 2015; Maintz, 2008; Stanley & Rocio Montero Fortunato, 2022). It is in Mexico where it is identified in a greater proportion due to the geographical and sociodemographic characteristics of the country (Silva, 2019).

The medical area uses the benefits of online education, seeking constant updating (Idris et al., 2021; Peloso et al., 2020; Salas-Pilco et al., 2022). Thus, the words “medical education”, “orthopedic surgery” and “patient care” are grouped together. It is then the updating of skills through education that contribute to the curriculum of professionals in the sector.

The last grouping shows the comparative analyzes that have been carried out because of the pandemic in online education (Soria-Barreto, Ruiz-Campo, Al-Adwan, & Zuniga-Jara, 2021). In this way, online education in the university sector in Latin America is analyzed (Cerdá Suárez, Núñez-Valdés, & Quirós y Alpera, 2021).

6. CONCLUSIONS

The objective of the research was to identify trends in research on online education in Latin America in the wake of the COVID-19 pandemic. To achieve this, an RSL was carried out. The results showed the impact on university education during and after the pandemic in Latin America.

Although there were already universities that had online education in the region, the pandemic forced it to be implemented in all universities and educational programs. Online higher education has continued after the pandemic, allowing other forms of learning to be exploited. This is mainly found in regions that do not have the physical infrastructure for in-person education, as well as where geographical and demographic conditions are adverse, such as in Latin America. This needs to be considered to promote university education in the region.

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Chapter # 25

THE IMPORTANCE OF THE ROLE OF PROFESSIONAL SOCIALIZATION FOR EDUCATORS AS THEY ENCOUNTER INNOVATION IN CURRICULAR AND ARTIFICIAL INTELLIGENCE TECHNOLOGY

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ABSTRACT

Teachers throughout their professional lives and their career experiences have long been the focus of educational research. Educators at all levels, including primary, secondary schooling, and tertiary education, are faced with increasingly complex demands placed on them by society, expanding role of education, curriculum reforms, the increasing use of Artificial intelligence technology in the classrooms, and diverse environments in which teachers work. It is recognized that teachers' professional experiences encountered during their early years of professional practice and their first teaching year, also known as an induction year, has far reaching implications for teachers professional learning, development as well as their subsequent teaching career. Consequently, teacher professional socialization and retention in the profession to a large degree depend on professional experiences encountered in their working environments during early teaching years.

Keywords: teacher professional development, professional socialization, organizational learning, educator career, subject teaching, innovations in curricula, tertiary education, Artificial Intelligence technology in tertiary education.

1. INTRODUCTION

This book chapter presents the findings from the three case studies: the Framework for teachers' professional socialization in schools in early years of teaching in Ireland; Encountering Artificial Intelligence technology and the need for ongoing socialization and communities of practice in the tertiary teaching profession; and the Importance of the role of professional socialization for new educators as they encounter innovations in curriculum.

2. CASE STUDY ONE: THE IMPORTANCE OF THE ROLE OF PROFESSIONAL SOCIALIZATION FOR NEW EDUCATORS

Early professional socialization of teachers in early years of profession has long been the focus of educational research in Ireland and elsewhere (Killeavy, 2001; Kozina, 2010, 2013; McGarr & McCormack, 2014; Eklund, 2018; Nally & Ladden, 2020). With a considerable focus of the beginning years of teaching is being from the perspectives of proposing various induction structures, there is a documented lack of research into teachers experiences in schools. There is also a limited understanding in the professional literature of the process by which teachers emerge in their careers and there is an increasing need to

explore the origins of beginning teacher concerns as well as the context of their early professional experiences.

The literature review further identified a lack of detailed research into early professional socialisation of newly qualified teachers in Ireland. Nevertheless, studies which have been conducted appear to have distinct limitations: they did not conduct a systematic inquiry into what happens to teachers as they progress with their first teaching year; featured limited samples and; were primarily focused on the merit and effectiveness of induction supports available to newly qualified teachers.

2.1. Methodology

The case study one draws on a large-scale mixed-methods research. The data for this study was collected by means of a postal questionnaire administered to a sample of 1635 graduates of one tertiary higher education institution from both, the B.Ed (Bachelor of Education degree) and H.Dip (Higher Diploma degree) (primary) degree programmes; and a more recent desk-based literature review. The data was further supplemented by 52 semi-structured qualitative interviews with 26 teachers in their first year of teaching. The questionnaire data were analysed using SPSS 16.0, while interview data were analysed according to the guidelines suggested by Miles and Huberman (1994) and Patton (2002).

The 52 interviews were conducted for the in-depth exploration of the first year experiences of beginning teachers. We sought to get more elaboration on the findings in regard to teacher socialisation which was not solely possible with just using quantitative results. It was evident that the questionnaire data would not provide sufficient insights into experiences of teachers, and it was believed that the interviews would provide more detail on numbers in the questionnaire and allow for more in-depth analysis of the recurrent issues.

The qualitative data was analysed by developing categories of information which then compared for each participant for divergent and convergent themes, and data triangulation. This approach is specifically used to work with unstructured data allows building a framework from most of the data. The analysis of these socialization experiences was principally conducted for the mainstream classroom teachers.

With regard to answering the research questions and interpreting the results, quantitative and qualitative data carried the same weight when interpreting and drawing conclusions from this study. The corroboration of numerical and textual data was achieved by matching quantitative and qualitative codes when reporting and interpreting the data. In cases, where no quantitative items were available to support qualitative data, interview themes were discussed as special/deviant cases. The quantitative and qualitative data were initially analysed separately then combined and compared in the data presentation and discussion sections. The descriptive statistics were used to report on the dimensions of the quantitative data.

2.2. Results

The specific emphasis of this study was on exploring early professional experiences of primary teachers in their first teaching year. The literature review on the issues, challenges and processes by which teachers emerge early in their careers has shown that the existing models and perspectives on teacher socialization, learning and development do not allow for a complete understanding of how new teachers become fully-fledged professionals and proceed through their first teaching year. It appeared that teacher socialization is a highly individualised process, which is dependent on the combination of personal characteristics of teachers and the context of their working environments (see the summary of the literature review findings from various sources and references to specific literature presented in Figure 1).

Based on the in-depth desk-based literature review (some of the sources presented in Figure 1) the following conclusion could be drawn, firstly that the general concept of socialization has its origins in three disciplines of psychology, sociology and anthropology. Psychology looks at the development of the characteristics of individuals which are relevant to social behaviour and the processes by which such development proceeds. Sociology focuses on the interactions in groups, social relations and how individuals and groups are socialized. It also considers the impact of institutions and the organisational settings in which socialization occurs. Anthropology considers socialization from the standpoint of the broader culture, constituted by a set of shared norms and beliefs and behaviours which helps to determine the overall content and scope of socialization. In particular, roles and role systems are central to the anthropological field as by and large, individuals have to confront potential new roles throughout their life-course. Importantly, regardless of whether the focus is on the development of personal or social identity or on the adaptation of the individuals to formal and informal norms of the specific groups and society, it is important to recognise that all experiences occur in social contexts - some very formal, organised and structured and others less so. The empirical uses of the term of teacher socialization have been generally influenced by a number of distinctive research traditions in which to look and understand the process of teacher socialization.

Figure 1.
Approaches to study teacher socialization.

Structural-Functionalist approach	Studies
<u>Underpinning assumptions:</u> Origin - French tradition of social thought (Durkheim, 1938), which holds the general possibility providing true explanatory and predictive knowledge of the studied phenomena. Aims at giving precise explanations to how society is organised and how it functions. Within teacher socialization framework the main focus is placed on teachers' inculcation of knowledge, skills and attitudes which are fundamental to teaching profession. The emphasis is on the measurement of teachers' attitudes and orientations toward their role and a variety of educational matters, before and after a certain period; and subsequent determination and explanation of the occurred change. Particular attention is given to the period of formal education in teacher training institution and its influence on the orientations of prospective teachers. The importance of teachers' subjective experiences and their interpretation is diminished. In order to become a member of the teaching profession, a teacher has to confirm to the norms, values and behaviour patterns associated with the profession. Research methods – quantitative (eg. questionnaires)	(eg. Algozzine, Gretes, Queen, & Cowan-Hathcock, 2007; Drew, 2006; Gilbert, 2005; Kelly, 1970; Killeavy, 1998; Lortie, 1975; San 1999; Smith & Ingersoll, 2004)

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Interpretative	Studies
<u>Underpinning assumptions</u> Origin - German tradition of social thought (Weber, 1965), which serves as umbrella for the following schools: hermeneutics (Gadamer, 1975), ethnomethodology (Garfinkel, 1967) and phenomenology (Schütz, 1967). Specific focus is on the “emergent nature of social organisation” (Burrell & Morgan 1979, p. 108) rather than on its structure. Within teacher socialization framework the main emphasis is on understanding of the process of becoming a teacher. Looks at teachers’ interpretation and subjective meanings which they give to their experiences. It also aims at getting an insight into whether and how teachers’ behaviour changes according to the demands of particular situations. Research methods - qualitative (eg. interviews, observations)	(eg. Hebert & Worthy, 2001; Lacey, 1977; Kauffman, Moore, Kardos, Liu, & Peske, 2002)
Critical (conflict model of socialization)	Studies
<u>Underpinning assumptions</u> Origin - Frankfurt school of critical theory, based upon Marx’s system of philosophy. Within teacher socialization framework the importance is given to both human agency and structure during the socialization process, while the teacher is at the centre of attention (Weiler, 1993). The questions of power imbalance, inequality and repression, which are mediated by power configurations within the teachers’ work context are raised and investigated. Research methods – mixed qualitative and quantitative (eg. questionnaires, interviews).	(eg. Kuzmic, 1994; Kelchtermans & Ballet, 2002)

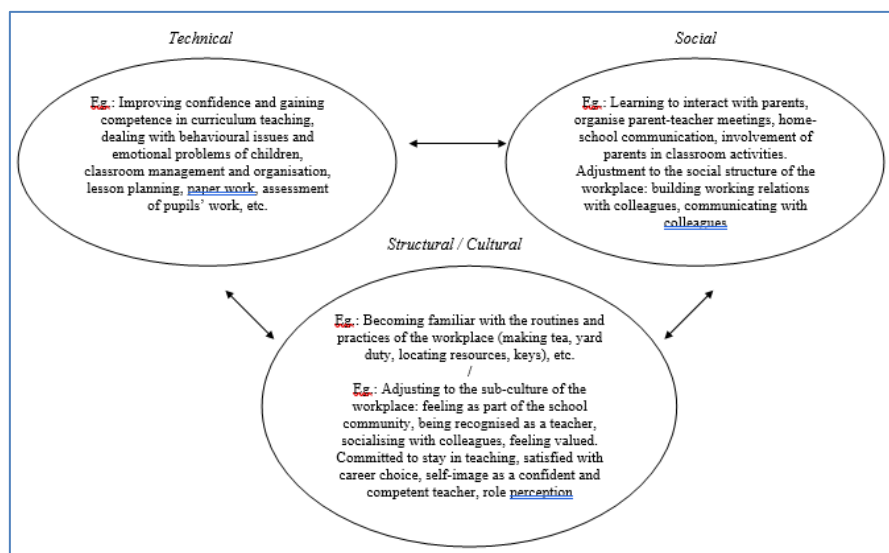
In particular, these traditions generally determine the way the research on teacher socialization is carried out, the type of questions it is trying to answer, the methodology it employs and how the gathered data is presented and interpreted.

More specifically, teacher professional socialization in the first teaching years, as was shown in this mixed methods research, in a broader sense reflects a process through which teachers become more competent in applying acquired knowledge and skills and which reflects teachers’ assimilation into their local working environments, as well as the culture of the profession.

Within the context of the case study one, the findings from teachers’ responses are presented from the perspectives of the issues within challenging of classroom teaching, self-image and school environment.

A three-dimensional model of teacher socialization developed as a result of this study within which relevant factors and teachers’ experiences can be explored and discussed has three interwoven domains as presented in Figure 2: *technical, social, structural / cultural*. Within the context of this study, they reflected teachers’ professional experiences within the areas of classroom teaching, relations with pupils, parents, colleagues, teachers’ self-image and teachers’ assimilation into sub-culture of their working environments as well as the culture of the profession. In addition, the first domain reflects the experiences of classroom teaching as beginning teachers gradually gain their competence and confidence in application of knowledge and skills acquired during their time in teacher education college in the process of their gradual induction into the life of a teacher.

Figure 2.
Developed three-dimensional framework for teacher socialization
(experiences in the first teaching year).



From the discussion above it appears that the concept of teacher socialization falls short of conceptual clarity. The research in most cases attempts to provide examinations and descriptions of teacher socialisation thus, capturing a multidimensional nature of this phenomenon. The research presented in case study one has shown that the outlined models and perspectives on teacher socialization and development do not allow a complete understanding of how new teachers learn to teach, become fully-fledged professionals and proceed through their early teaching years. A three-dimensional model of teacher socialization developed as a result of this study (presented in Figure 2), nevertheless, can enrich our understanding of the issues, challenges and processes by which teachers and educators emerge in their early careers. It appears that teacher socialization is a highly context specific and individualised process, which is dependent on the combination of personal characteristics of teachers and the context of their working environments.

2.3. Future Research Directions

The research in a case study one has collected empirical evidence on primary teachers' professional socialization, specifically teachers' professional experiences faced regularly in classrooms and a wider school environment. The focus was on how newly qualified teachers progress through their first year of teaching. The findings have implications for future pre-service preparation of primary teachers and provision of induction support in their first year of teaching. The findings from this research may be used in production of teacher training materials, making recommendations on policy making, and design of effective induction programs.

3. CASE STUDY TWO: ENCOUNTERING ARTIFICIAL INTELLIGENCE TECHNOLOGY AND THE NEED FOR ONGOING SOCIALIZATION AND COMMUNITIES OF PRACTICE IN THE TERTIARY TEACHING PROFESSION

At the tertiary teaching level within larger colleges and universities educators can be siloed within disciplines with less opportunities for socialization beyond their immediate colleagues and students. Yet all disciplines regardless of their topic are subject to the use of overarching technologies within the classroom. These include databases hosting lecture notes, submitted assignments and online exams and workbooks. One of the greatest disruptors within the educational system has been the emergence of artificial intelligence (AI). As with all disruptors it can be welcomed or feared. The role of peer communities during this period is essential.

To address this challenge with staff one tertiary college took a holistic approach to AI implementation and provided a range of supports. The enablers and barriers of successful implementation have been well documented and are summarized in Figure 3. We can see from this table that it also reflects the three dimensional framework identified earlier in Figure 2. The importance of the socialization of the technology across stakeholder groups, the importance of a supportive culture in terms not only of physical resources but also from leadership and wider college supports and finally the importance of wider technical training.

Figure 3.

A summary of implementation enablers to be addressed when introducing AI technology to third level educators (adapted from Burke, Morris, & McGarrigle, 2012).

Enablers	Stage of Implementation			
	1. Exploring and preparing	2. Planning and resourcing	3. Implementing and operationalizing	4. Business as usual
Leadership				
Resources				
Educator consultation and buy-in				
Supportive college culture				
College support				
Implementation plan				
Implementation teams				
Staff training				
Communication				
Monitoring and evaluation				
Learning from experience				
Barriers across the implementation stages	External environment; resistance to change; vested interests			

Within one tertiary college many of these aspects were addressed to enable the educators, students and professional and administrative staff to learn about the benefits and challenges of AI in relation to their role.

Leadership invested in developing a series of introductory workshops where peer educators could share learnings on AI technology over a lunchtime event. This created both an opportunity for socialization and for learning within a supportive and open environment. Questions could be asked, fears expressed and knowledge shared. The ethics of AI were also addressed (Foltynek et al, 2023).

Additional enablers were addressed through the consultation and drafting of an AI policy. This draft was shared amongst all levels of staff for input and comment. This demonstrated a supportive college culture, leadership and good shared communication and discussion of the policy in smaller discipline groups. It enabled the socialization of the policy and its communication among staff in an open dialogue.

Finally, to enable AI development, small bursaries were offered to staff in the form of innovation teaching awards. These could be used by educators to trial and test AI and other technology in the classroom. This also addressed and added to the important enabler of resourcing. One such successful project was in the use of AI to teach and interpret statistics within a cohort of healthcare students. The International Association for Statistical Education demonstrated that students learning introductory statistics often struggle to understand and apply the concepts of statistical modelling and the logic of hypothesis testing. To address this an Artificial Intelligence (AI) assisted Statistical Support Web teaching tool was developed. The pedagogical underpinnings of this innovation included the Learner-Centred Approach and the Problem-Centred Approach, both of which are recommended approaches for teaching natural science and technology (Comiskey, Basa, Banka-Cullen, 2023). The web app aimed to provide personalized recommendations based on the imputed student's study question. In summary, it was anticipated that the approach had the potential to significantly enhance student learning outcomes and prepare future healthcare professionals and future healthcare educators for success in an AI data-driven world.

To conclude, the need for sustainable, communities of practice which support the ongoing socialization of educators as they progress through their careers from early to later stage is essential. In a world where we are faced with constant disruptors be it local or community initiatives or global pandemics, conflicts or international AI developments, this need has never been greater.

4. CASE STUDY THREE: THE IMPORTANCE OF THE ROLE OF PROFESSIONAL SOCIALIZATION FOR NEW EDUCATORS AS THEY ENCOUNTER INNOVATION IN CURRICULAR

The socialization of new educators is a process of both formal and informal learning. Acquiring the necessary skills, knowledge and behaviour to be effective educators is firstly gained through a formal education of theoretical and pedagogical programmes. This is followed by a period of adaptation with guidance and mentorship from professional teaching colleagues, within a school culture. The socialization of new educators is greatly influenced by their environment and the school culture which implicitly shapes their expectations and values as educators. Influential mentoring and socialization significantly enhance professional identity, integration with peers, and enriches teaching practices for new educators (Zeichner, 2010). With superior socialization comes greater contribution and innovation within teaching practice, to tackle curricular changes. By fostering a network of

mentors and colleagues, new educators absorb new technologies, innovative practices and stay flexible to curricular challenges. Professional socialization provides new educators with strategies to better implement curricular innovations within the school culture (Day & Gu, 2010).

However, as new topics emerge on the curriculum, for example Social, Personal and Health Education (SPHE), which is a mandatory subject taught in both junior and senior cycles, challenges are evident. New educators may return to school in September to find an SPHE classes on their timetable without any prior knowledge or training. New educators may feel overwhelmed or inexperienced to discuss and tutor adolescent students on topics such as gender identity, sexual relationships and substance use. This requires new educators to manoeuvre through a minefield of inclusivity and non-discriminatory language not to inadvertently cause offence to any of their students. The relaying of personal experiences and the relaying of student's experiences are discouraged during classroom discussions and workshops, adding to the complexities of navigating these sensitive topics. As a non-exam mandatory subject on the curriculum, it is often unconsciously relegated in comparison to the core subjects without realising new educators may feel professionally uncomfortable and incompetent to teach a subject which requires an adjustment to their teaching methods.

Through professional development and collaborative networking, experienced educators need to enhance the levels of confidence and efficacy in the teaching of sensitive topics. New educators need to feel part of a professional learning community, where professional socialization and mentorship offers opportunity for sharing challenges and the development of creative solutions (Paula & Grindfelde, 2018). Once new educators are integrated into their professional communities a more diverse range of perspectives and professional creativity can be adapted, which is culturally appropriate (Gay, 2018). As new educators feel supported through professional socialization within their educational communities, they are more likely to adapt to change, initiate innovative practices, and adopt on-going professional learning throughout their career.

5. CONCLUSION

This book chapter presented the findings from the three case studies: the Framework for teachers' professional socialization in schools in early years of teaching in Ireland; Encountering Artificial Intelligence technology and the need for ongoing socialization and communities of practice in the tertiary teaching profession; and the Importance of the role of professional socialization for new educators as they encounter innovations in curriculum.

In conclusion, a positive professional socialization of new educators is fundamental in developing efficacy and successful adjustment amidst changing curricula. Therefore, schools must foster collaborative networks amongst their educators to ensure new educators are well inducted, mentored and supported to become competent and innovative in their practices to meet the needs of their students.

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Professor Comiskey has over 30 years research and lecturing experience in statistics and mathematics applied to healthcare and her personal research interests are in substance use, child wellbeing and innovation. From 2020 to present Professor Comiskey was elected by EU members as Chair of the Scientific Committee of the European Monitoring Centre for Drugs and Drug Addiction, a committee with a legal remit from the EU.

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Chapter # 26

VIEWS OF LEARNERS ON TRANSFORMING SCHOOLS INTO MORE INCLUSIVE SPACES

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ABSTRACT

Inclusive education has gained prominence as an essential educational approach throughout the world. In the South African context, inclusive policies recommend the active participation of learners in the education process to develop and extend their potential as equal members of society. This study explores the perceptions of learners regarding inclusive education and its potential to improve teaching practices. This participatory research study, using transformative learning theory as a lens will employ photovoice and narratives. The participants were 25 full-service school learners in Gauteng and North-West Provinces of South Africa. Thematic data analysis was used to analyse the data. The study findings revealed that learners do not have a voice in the implementation of inclusive policies; only teachers are privileged to influence inclusive teaching, while learners are only expected to be recipients, and that learners are treated as empty vessels. Although the study has found that learners are disadvantaged in contributing to inclusive practices, it recommends an integrated approach among teachers, learners, and education policy developers to ensure that learners' voices are heard in schools to improve inclusive teaching practices.

Keywords: inclusive education, learners' voice, full-service school, photovoice, inclusive teaching.

1. INTRODUCTION AND BACKGROUND

Inclusive education evolved as a social issue that promotes human rights while challenging any exclusionary policies and practices. The benefit of inclusive education is understanding collective stories that include teachers and learners as stipulated in the South African Constitution Act 108 of 1996, to be a way of upholding a democratic state where all learners pursue their learning potential to the fullest (South Africa, 1996). Hernández-Torrano, Somerton, and Helmer (2020) argue that asking adults about the views of learners is no substitute for their (learners') input. Therefore, since learners are beneficiaries of inclusive teaching approaches (Crawford & Tindal, 2006) in this study, we wanted to hear their perspectives to allow them an opportunity to add their views to enhance inclusive education implementation. This is affirmed by the Global Education Monitoring Report (2020) and Mabasa (2021) which state that learners must be at the centre of what the education system and schools do by considering their views, experiences, and opinions.

The prominent focus in the literature on inclusive education is on the role of teachers, teacher training, and other aspects (Engelbrecht, 2020), while the quality and relevance of inclusive education can be better enhanced by including learner perspectives on its implementation. To fulfil this mandate, a screening, identification, assessment, and support (SIAS) policy requires that learners be involved in the decision-making on how this support is carried out (DBE, 2014). Although policies such as the Education White Paper 6 [EWP6] of the Department of Basic Education (DBE), highlight that inclusive education is based on

social justice for all learners (DBE, 2001), but learners' voices are still missing, although it is a catalyst for the promotion of inclusive education (Messiou, 2019). The voices of the learners include their thoughts, emotions, views, and actions to bring about change (Mangiaracina, Kafallinou, Kyriazopoulou, & Watkins, 2021).

Moreover, EWP6 further classifies schools, according to the severity of disabilities in which learners experience barriers to learning, to receive additional support (DBE, 2001). Learners with severe level of support needs are accommodated in special schools while full-service schools cater for those learners with moderate level support needs and the mainstream school for those with low level support needs. Full-service schools came into existence as part of South Africa's journey to fulfil the mandates of inclusive education (Ayaya, Makoelle & Van Der Merwe, 2023). Even in full-service schools, the preference is to place learners with learning barriers in separate special classrooms (Engelbrecht, 2020), thus reinforcing the idea that inclusive education is a renamed special education (Engelbrecht, 2019). Against this background, Messiou (2019) asserts that if learners' voices remain marginalised, it impedes the quality necessary for the relevance of the education provided to each learner because their ideas are critical to the formation of school practices. He further suggests a critical role of collaborative participatory approaches in the field of inclusive education, as they allow co-researchers time to have detailed discussions about learning and teaching, thus opening opportunities for the empowerment of all participants who are part of the research. Mangiaracina et al. (2021) assert that the perceptions learners have of themselves and of their learning are crucial to inform teaching and learning practices. Therefore, Ainscow and Messiou (2018) developed an inclusive inquiry that involves talking about diversity, learning from experience, developing inclusive practices and engaging the views of learners. Research indicates that learners' views make a difference in responding to learner diversity (Messiou, 2019) and in addressing behaviours such as bullying (Siperstein, Ballard, Jacobs, Rodriguez, & Shriver, 2022), thus inventing new possibilities to introduce learner participation in school improvement. In a study conducted in Gauteng Province of South Africa on how learners' voices can impact the quality of teaching in full-service schools (Ayaya, 2021). The findings revealed that learners in a full-service school often feel embarrassed when a teacher asks them a question they cannot respond to. The learners' voices in the study highlighted scenario's teachers need to be familiar with and therefore avoid. The following came as an impact brought about by their participation:

- A deeper understanding of how best they can be taught,
- Uncovers how family and social circumstances affect inclusive practices,
- It also transforms teachers' thinking practices as they were challenged to be innovative in their teaching practices.

Learners' voices led to flexibility, choice, and collaborative experiences as they indicated that they benefit much when it is their peers that are explaining the work to them. In cases where learners are taken as experts of their learning, teachers tend to be informed on how they can support these learners (Scarparolo & MacKinnon, 2024). According to Education White Paper 6 (DBE, 2001), inclusive practices include converting primary schools to full-service schools. Conversion of schools does not lead to inclusive processes, which include differentiated curriculum, inclusive pedagogies, as well as sense of belonging to learners who were previously excluded in learning processes (Shapiro, 2020). For inclusive practices to be accommodative to all learners, these learners need to be allowed space to express their desires, interests, and strengths so as to inform the teaching strategies used by their teachers (Bolourian, Losh, Hamsho, Eisenhower, & Blacher, 2021). Collaboration among stakeholders is also mandated by the SIAS policy (DBE, 2014), as it promotes togetherness with the intentions to reach the final goal of being inclusive in every way

possible. Ownership, self-reflexivity and awareness are important aspects in inclusive practices additional to accommodation based on adapting content and process (Bonati & Andriana, 2021). Furthermore, Scarparolo and MacKinnon (2024) assert that the voice of learners needs to be sought for differentiated instruction, which is a participatory pedagogical practice to inform teachers' planning. Giving learners a voice in how they learn is seen as a democratic principle that allows them to choose a focus area for their learning.

Therefore, we are determined to find out how learners' perceptions can be helpful in facilitating inclusive practices. In the past, learners experiencing barriers to learning were excluded from participating in education, but inclusive education needs to provide them with opportunities to actively engage in learning (Karimupfumbi & Dwarika, 2022). Furthermore, when learners are involved in the transformation of their learning by creating a sense of agency, an improvement in the implementation of inclusive practices can be different from what it is currently (Bonati & Andriana, 2021).

2. METHODOLOGY

Participatory Action Learning and Action Research (PALAR) is one of the types of participation action research that was used in the project. PALAR, as mentioned by Wessels and Wood (2019) is a holistic, integrative concept that incorporates related concepts and values such as participation, collaboration, communication, community of practice, networking, and synergy. PALAR is an integrated methodology of lifelong action learning (AL) and participatory action research (PAR) (Zuber-Skerritt, 2015:5). Kearney, Wood, and Zuber-Skerritt (2013) have identified the essential characteristics of the PALAR process as underpinned by democratic values and principles, clustered as the 'seven C's', namely, communication, critical reflection, commitment, coaching, collaboration, competence and character building and are developed through an action learning process grounded in the 'three Rs', namely, relationship, reflection and recognition. According to Wood (2019), PALAR follows a cycle commonly known as the cyclical PALAR process, which involves the following: Cycle 1 - Collaborative identification of needs (start-up workshop), Cycle 2 - Deciding on the best course of action and implementing the action (Action), and Cycle 3 - Evaluating it and then deciding what further action to take, based on the participants' critical reflection upon the process (Reflection). As part of what happened in the first cycle, at each site, we needed to have relationship building meetings, as they are helpful for co-researchers to agree on the primary research questions, also agree on the data generation methods, and for building trust among us (Neethling & Nel, 2021; Wessels & Wood, 2019). The PALAR approach allows all participants to take ownership of the solution to the problem affecting their community as they engage in a cyclical learning process through action, discussion, and reflection to achieve a mutual goal (Wood, 2019). Purposive sampling allowed 25 learners from full-service schools to be co-researchers (Creswell, 2014). The learners were recruited by an independent person to avoid power relationship issues, they were allowed to indicate their interest in the study, and their parents signed consent forms on their behalf (Luthuli & Wood, 2022). Photovoice, as a visual research method that allows participants to take photographs and make powerful statements about the issue while making their voices heard, was used to generate data (Evans-Agnew & Strack, 2022; Wood, 2019).

A photovoice is seen as a pedagogical tool that can be useful to amplify the voice of learners experiencing a barrier to learning (Smith, 2018). It bridges the gap between language barriers and expression of feelings without having to feel disempowered by insufficiency in vocabulary (Lögdborg, Nilsson, & Kostenius, 2020). Exhibition of the photovoice to the stakeholders concerned can influence their decisions, and every time teachers prepare

individualised support, their decisions will be based on the feelings associated with strengths-based lens to which learners point their own competencies (Eckhoff, 2019). It is also a recommended visual method to facilitate inclusive teaching practices, as it supports aspects of social inclusion when inviting the voices of learners in the support provided to them. Ciotoli (2019) asserts that a photovoice is a powerful form of agency in which learners are provided with an opportunity to express themselves while also developing their abilities to be vocal about their learning needs.

A prompt given to all co-researchers in three sets of action learning was 'take photos and write narratives that describe your perceptions of how full-service schools can be made more inclusive'. Two of the sets of action learning had eight members while in the other set of learning, nine co-researchers 'take photos and write narratives that represent your perceptions of how full-service schools can be made more inclusive'. Each person was expected to take an individual photovoice and this was after what this visual method entails was explained and a discussion was also carried out in which ethical considerations like avoiding taking photos of human beings were communicated. Thereafter a discussion of why a particular object was chosen and how it relates to the research problem was followed to enrich data from individual photovoices. Data was thematically analysed using the six steps of Braun and Clarke (2014) namely: familiarising ourselves with the data, generating initial code, searching for the themes, reviewing themes, defining and naming the themes, and finally writing up the report as informed by the findings.

In this study, the integration of transformative learning theory forms a solid foundation for understanding and fostering inclusive education. Transformative learning theory, as proposed by Fleming (2022), underscores the active contribution of learners in their own learning processes, emphasising the need for effective changes in individuals' frames of reference. This theory challenges the common tendency among teachers to dismiss ideas that do not align with preconceived notions, advocating for an inclusive educational space where learners' perspectives are valued (Messiou, 2019). Uddin (2019) further contributes to the discourse by emphasising the importance of allowing learners to have a voice in their education. According to Uddin, teachers play a crucial role in making inclusive education meaningful by showing interest in meaningful learning experiences and employing suitable strategies that encourage the participation of the learners. Uddin's perspective aligns with transformative learning theory, emphasising the active role of learners in shaping their educational experiences.

The synthesis of transformative learning theory is particularly powerful in the context of inclusive education because it emphasises the need to challenge existing norms and oppression systems and promote equity, making it more relevant to this study, which looks at learners' views as opposed to taking into consideration teachers' voices only. Therefore, the application of transformative learning theory underscores the importance of creating an open and inclusive educational space that not only acknowledges diverse ideas but actively seeks to break away from traditional tendencies that can hinder inclusive practices. This theory suggests that to make inclusive education meaningful from the perspective of learners, teachers must embrace transformative practices. This approach encourages teachers to recognize the value of diverse ideas, actively involve learners in decision-making processes, and implement strategies that foster meaningful learning experiences. In addition, it emphasises the potential for transformative change and collective action between teachers and learners to create more inclusive educational spaces (Uddin, 2019).

Ethical clearance was received from the Research Ethics Committee of the North-West University, with the number (NWU - 00413 - 23 - A2), and the adherence to justice, beneficence, and respect for the people were considered. This research was carried out in the Gauteng and Free State Provinces of South Africa. Since our participants were learners, parental consent was also sought from parents of learners who participated, and the learners just gave their assent.

3. PRESENTATION OF FINDINGS AND DISCUSSION

The following themes emerged during the analysis of the data from this study: Learners experiencing learning barriers have no voice in inclusive policies, teachers are privileged to influence inclusive teaching, while learners are only expected to be recipients, and learners are seen as empty vessels. For the benefit of this chapter, it is important to note that even though we had 25 participants working in three action learning sets, this study presents only a few responses representing each action learning set due to the restricted number of words expected for the book chapter. The themes that emerged are presented and discussed in the section that follows.

3.1. Theme 1: Learners Experiencing Learning Barriers Have No Voice in Inclusive Policies

Participants relate their expectations of participating in the supported program envisaged, as well as their participation, determining the type of support to be provided to them in a full-service school. However, these participants noticed many challenges that hinder them from accessing efficient support provision in full-service schools. Amongst the challenges, the following were highlighted by participants as critical: getting support depending on what teachers see necessary, no teacher bothers to find out from learners in what ways they can be supported, a big gap between learners and teachers; and learners do not have any opportunities for input on what support should be provided to them. This finding is well rationalized by a photo taken by Participant 1 in Figure 1 where she showed a blossom out from the flower planted within the tire. The flower is surrounded by some old, cracked bottles that she compared with the challenges of getting support in a full-service school. Furthermore, the photo in Figure 2 was presented by Participant 4 who has the same impression as the Participant 1. In this photo there is an open area used as assembly when the teaching day starts and there is a classroom that indicates where she actually belongs. The narration in this photo suggests the strength of this participant, as it is aroused from being in the company of other learners who are determined to get an education despite the obstacles caused by barriers they face. However, Participant 4 also mentioned a large gap between them and teachers as a challenge because this gap hinders opportunities to give their input on the kind of support that should be provided to them in a full-service school.

*Figure 1.
Photovoice 1.*



This picture reminds me of how I saw my education when I was referred to a full-service school. I hoped to get support that would make my future blossom like this plant. The surroundings around the plant represent challenges such as getting support depending on what teachers see necessary, and no one bothers to find out in what ways I can be supported. Life in a township is also a challenge, as it is influenced by many things that lead many of us to drop out of school [Participant 1].

*Figure 2.
Photovoice 2.*



I took this picture to show my sense of belonging when I joined a full-service school. Being in the company of other learners who are determined to get an education despite the obstacles caused by barriers they face, gave me hope to achieve the education that I long for. The only challenge is that there is a large gap between us and teachers; as learners, we do not have input on what support should be provided to us as part of full-service teaching practices [Participant 4].

Munna and Kalam (2021) reflect on the value of involvement of learners in their education and describe it as glue that holds together all aspects of the learning and growth of learners that ultimately allow them to excel academically. However, although inclusion policies promote the participation of learners in their education, they do not allow learners to influence its implementation. The findings of this study highlight that learners make no contribution to how inclusive policies are implemented, and this becomes another barrier to their learning. This finding confirms Messiou (2019) and Uddin (2019) when they claim that inclusion can only manifest when the voices of learners are also heard as necessary to achieve quality education and other school practices. It also magnifies what Engelbrecht (2019) and Mabasa (2021) state, where full-service schools are said to reinforce marginalisation of learners experiencing barriers to learning as their views are not considered to be central in their learning.

3.2. Theme 2: Teachers Are Privileged to Influence Inclusive Teaching, While Learners Are Only Expected to Be Recipients

Most of the participants agreed that teachers in full-service schools have a privilege to influence inclusive teaching, and this portrays learners as mere recipients of inclusive education. Being unable to attend to the loneliness of learners, disallowing learners to share their opinions, being excluded from the teaching practices that are supposed to accommodate their learning needs, has emerged as factors that liberate teachers to have greater influence in inclusive teaching. In addition, it is perceived that they have a huge impact on the performance of the participants that led them to believe that they are just recipients of inclusive education, and no platform is created for them to have a say. In this respect, the photo in Figure 3 as captured by Participant 20 resembles a lonely learner in the school premises where there are neither teachers nor learners around. This equates with the loneliness she experiences during teaching and learning, whereas she knows how she can learn best in an inclusive setting. In her narrative, the participant explicitly reflects on her feeling that learners are treated as recipients of what teachers think will work for them. The understanding in this finding is that learners perceive inclusive education as being imposed on them, and the expectation is just to follow what is recommended for their support. Moreover, the photo and narration in Figure 4 from Participant 14 concur with this finding. This participant took a photo of a ruined school bag lying on the floor. The narration in the photo relates to his helplessness and low self-esteem that comes with being excluded from the inclusive teaching practices that are supposed to accommodate their learning needs. The most interesting fact is that the participant is aware of the existing support provided to him in a full-service school and acknowledges that it brings back long-lost hope, but still feels excluded when it comes to the support that should be provided.

*Figure 3.
Photovoice 3.*



I took this picture to show the loneliness that I experience in all the classes. Although I am in school, when teachers teach, I feel lost, like this girl, because even though I know how I learn best, no one bothers to find out what I prefer. I feel like we are just treated as recipients of what teachers think will work for us. Sometimes, even when I want to share my opinions, I get scared that when I see some teachers, I will look like I am undermining their professionalism [Participant 20].

*Figure 4.
Photovoice 4.*



This picture shows the helplessness and low self-esteem that come with being excluded from the teaching practices that are supposed to accommodate my learning needs. The bag is ruined representing the discouragements that I experienced in the mainstream school, as other teachers and other learners criticized me. Although there is support that I receive in a full-service school that brings back long lost hope, I feel excluded when it comes to the support that is supposed to be provided to me. I see myself as a mere recipient of support. Whatever comes to us is packed up there for us, as if we are just recipients who must just take what is provided. [Participant 14].

In the above extracts, it is evident that even though learners saw a future when they were referred to a full-service school, the dominant voice of influence is that of the teachers, while learners are just recipients of what teachers thought best for learners. This contradicts Uddin's (2019) point of view, which highlights that although teachers are expected to play a crucial role in employing suitable strategies, it does not overrule the importance of collective union between teachers and learners to create more inclusive educational spaces (Uddin, 2019). Furthermore, excluding learners to whom the support is prepared in the planning process so that they can have a say, seems to be a perpetual oppression on the learners experiencing barriers, as they have no control and voice to what is given to them. This defeats the expression 'Nothing about us without us', which was used as an opposition to the oppression experienced by people with disabilities (Charlton, 1998:3).

3.3. Theme 3: Learners Perceived as Empty Vessels in Inclusive Education

In this theme, it emerged from the participants that inclusive education exists in their school but their nonparticipation in determining its implementation made them think they are perceived as empty vessels. To illustrate this, Participant 2 took a picture of an empty bag hung on the closed window and provided a narrative, as shown in Figure 5. In her description of the picture, she mentioned that the empty bag looks like inclusive education, whereby no teacher is prepared to hear from learners how they perceive their support package. In this way, inclusive education will provide minimal support to learners experiencing barriers to learning, as the best support package can be derived from the learners themselves. The poor system of education has negative effects on learners because they leave school without having acquired the basics, which greatly impedes the social and economic development of the countries from which they come from. Furthermore, Participant 13 confirms the emptiness of inclusive education to them as he equates it to the empty chairs and table in his photo (Figure 6). His emphasis on emptiness is that teachers do not care to know what his interests and preferences are, and he does not have a say to what teachers do to support him, even when their practices are of no help.

Figure 5.
Photovoice 5.



This bag refers to how education is for us in the so-called full-service schools. When referred to a full-service school, I thought I would have a better opportunity to tell which teaching practices can make it easy for me to access education, but I noticed that it was not different from where I came. When you go to a full-service school, the expectation is that additional support is sure, but when you get to the school, it is something that you cannot influence. This makes me feel that the inclusive system of education is empty to us like that bag, because no teacher is prepared to hear from us how we perceive our support package. [Participant 2].

*Figure 6.
Photovoice 6.*



This picture represents inclusive education in a full-service school. From this picture you can see the emptiness, only empty seats and tables. I perceived our education in this full-service school as if it is empty as these chairs, no one cares to know what my interests and preferences are, I do not have a say in what teachers do to support me, even when their practices are of no help to me. [Participant 13].

The significance of the narratives mentioned above lies in the idea that while teachers ensure the effective implementation of inclusive education without consulting the learners during the process, they also discourage learners from accepting any form of support provided and fail to prepare them to have the necessary skills that will enable them to cope when they finish school. Mayimele and Makhalemele (2020) warned that if learners at risk are exposed to lack of support, their academic performance is negatively impacted, and they may withdraw from schools. Buckley and Lee (2018) added that such learners may have less time to devote to non-academic activities than other learners.

4. CONCLUSION AND RECOMMENDATIONS

This chapter aims to explore the perceptions of learners about inclusive education and its potential to improve teaching practices. The findings revealed that learners do not have a platform to influence the implementation of inclusive education and a variety of challenges that hinder their participation were raised. However, this study was not expected to generalize but to focus on the sample that was limited to the accounts and experiences of people in a specific context.

Surprisingly, learners feel that even though they are in a full-service school, there is no hope in their education, as there is still a gap between what teachers do and what learners would like to be done when it comes to the support they receive. Furthermore, they feel excluded from full-service schools, as was the case when they were in mainstream schools. They do not see any implementation of inclusive policies where they are supposed to also have a voice. This implies that, even though being referred to a full-service school, brought some hope to these learners, thinking that they will get prepared for their future careers.

The barrier at hand now is teacher domination that does not allow them space or opportunities to contribute to such inclusive practices. It is necessary to ensure that inclusive teaching practices are collaborative, as learners guide support providers about their learning styles, preferences, and other aspects that may help ensure that the support given addresses the barriers experienced.

On the other hand, teachers in full-service schools should know how they can engage learners as equal members in support provision. The support services led by the school-based support team and the district-based support team need to incorporate what inclusive policies recommend, which is to ensure that learners who are receiving support should have a voice in whatever support is prepared for them. Based on the findings of this study, it can be noted that there is still a gap between what teachers do and what learners would like to be done when it comes to the support they receive. Additionally, learners feel excluded in full-service schools, as was the case when they were in mainstream schools. They do not see any implementation of inclusive policies where they are supposed to have a voice. This implies that although being referred to a full-service school brings some hope to these learners, the barrier at hand now is teacher domination, which does not allow them space to contribute to such inclusive practices.

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Chapter # 27

PERSONALIZING LEARNING THROUGH COLLABORATIVE NETWORKS OF KNOWLEDGE

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ABSTRACT

Over the past two decades, numerous learning systems have emerged promising novel approaches to improve education and training. However, most rely on exposure to information and practice, which does not guarantee the internalization of the concepts and changes in behavior required to engage the learner appropriately in education and training. This paper presents a new learning process that addresses these limitations by modeling, motivating, guiding, assessing, and attesting the learner. We present each of these steps and discuss how leveraging innovative knowledge structures using network science, emerging technologies, and AI, can support the proposed learning system that engages learners in their learning journey. The system's effectiveness is illustrated through two pilot studies on two different learning systems, a process that integrates: (i) a theoretical framework developed based on data on student learning and (ii) on student and faculty experience undergoing years of testing and refinement based on faculty expertise and learners' experiences, shaping the systems' designs and outcomes.

Keywords: networks of knowledge, individual learning pathways, personalized education, micro-learning.

1. INTRODUCTION AND MOTIVATION

Learning is shaped by how individuals receive, internalize, and use information (Huitt and Hummel, 2003). Factors such as experiences, biases, environments, and cognition influence the way learners engage in the process. Traditional education systems often push knowledge at students through compulsory or comprehensive curricula without ensuring such content has relevance to each student's current needs and competencies. Instead, these systems emphasize a long-term payoff, which can demotivate the learners. Instead, learning should be designed to meet each student's current needs and interests, in a timely manner.

A personalized learning and development system (LDS) must recognize and adapt to each learner's traits. The proposed LDS adjusts content based on three factors: 1) learner competency, to address personal cognitive load and working memory; 2) structuring and organization of learning activities; and 3) ability to control the engagement within a collaborative learning model. Information technology enhances the system by modeling, guiding, motivating, and assessing,

The role of network science is emphasized in the creation of personalized learning pathways, using a dynamic network of knowledge as a foundation to design tailored learning experiences. By providing a system that supports self-directed and self-paced opportunities, the LDS meets individual learning goals within a participatory learning environment. Such efforts push the limits of the current educational systems, tools, and a learning system's capabilities to create a personalized educational experience enhancing learning outcome achievement.

2. THEORETICAL BACKGROUND

This section synthesizes components of learning science and network science components addressing the extrinsic and intrinsic motivation of learners.

2.1. Learning Science

Learning occurs when individuals process, organize, and connect new information to preexisting ideas to create new meaning (Bransford, Brown, & Cocking, 2000). A learner's ability to receive, reflect, and internalize information, within the limitations of working memory and long-term memory, is an important consideration when designing an LDS. If working memory becomes overloaded, learners may struggle to process new information, disrupting the learning process (Cook & McDonald, 2008). Effective content design, including the design of activities, their structure, and the scaffolding and segmentation of content, is an important aspect of managing cognitive load.

Technology supports cognitive load management by using expert-guided instruction and micro-modules, also defined as CHUNKs, with opportunities to check for understanding (Gera, Bartolf, Isenhour, & Tick, 2019). These self-contained modules allow learners to pause naturally, reducing strain on the learner and restoring their ability to take in new information. Adaptive learning tools further personalize the experience by providing learners with critical feedback tailored to their specific challenges.

New learning system use models that automatically identify a learner's working memory capacity by analyzing the learner's behavior within the learning system (Chang, Kurcz, El-Bishouty, Kinshuk, & Graf, 2015). Thus, a personalized LDS would capture learning data, update learner characteristics, and adapt the recommendations presented to the learner. So, the LDS filters suggested content that is most relevant to each learner, mitigating the risk of overwhelming the learner while enabling the LDS to adjust recommendations, filtering learning content (Reith & Dever, 2021).

Learner agency within the personalized Learning Delivery System (LDS) empowers learners by giving them control over their learning process. The LDS would be designed to enhance understanding, ability, and opportunities for learners to take an active role in their education. This approach fosters engagement and reduces the cognitive load on working memory. Discussions of learning schemas as a necessary component of cognitivist learning theory form the basis of this research (Gholson & Craig, 2006). By creating mental representations of interconnected content, learners can establish connections between existing knowledge and new complex knowledge supporting improved retention and storage in long-term memory (Van Merriënboer & Sweller, 2010).

2.2. Collaborative Environments

In creating a student-centered learning environment within higher education, the goal is to facilitate learner knowledge creation through experience rather than simply transferring information from subject matter experts to learner. A collaborative environment can support

this by encouraging experiential learning, cognitive learning, participatory learning, case studies, discussions, and other problem-solving methods. These approaches leverage pre-existing resources available on the Internet to populate learning pathways (Feldman, Konold, Coulter, & Conroy, 2000). Learners navigate this networked environment as self-directed and self-paced users, supported by asynchronous or synchronous engagements.

The “Network of Knowledge” generates a mind map of concepts, providing an environment where subject matter experts can collaboratively contribute and tag content based on their expertise. This content is then connected in a non-linear way through prerequisites or dependencies, much like a mind map (Cleven, 2018). Existing prototypes already demonstrate real-time adaptive micro-learning methods, enhancing and personalizing education by using particular multimodal engagement for each learner as well as relating the content to each learner’s knowledge (Gera, Bartolf, & Isenhour, 2018).

A network science approach to learning addresses the challenges of information overload by guiding students through networked learning pathway recommendations that can screen out the extraneous content and focus the learner on achieving the set goals (while still seeing the connections to the extraneous content if desired). Self-paced learning has been practiced and empirically analyzed using intentional and meaningful learning supported by networked content and activities (Gera et al., 2019). An interconnected model of education introduces a non-linear perspective on knowledge to support its users. Thus, in a network science approach, learning support is modeled as a social network comprised of content creators, instructors, instructional support staff, stakeholders, sponsors, and learners.

3. CONTEXT OF THE RESEARCH

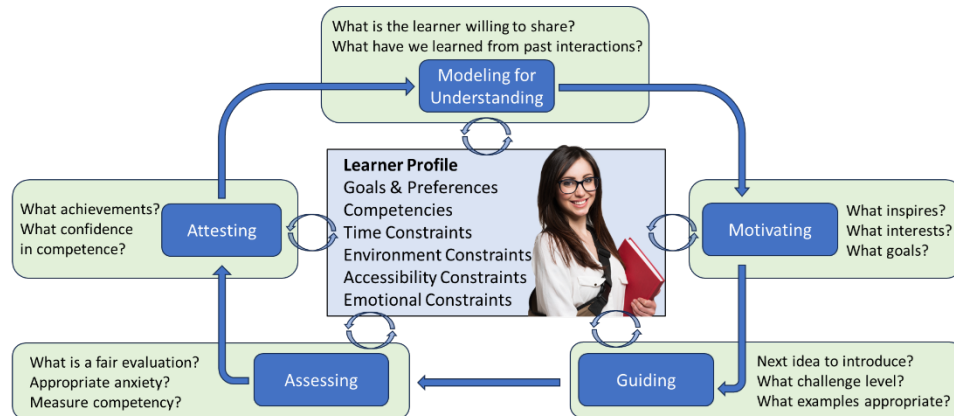
Supported by network knowledge and the network science approaches, the proposed model for personalized learning is designed for a networked environment inspired by existing frameworks. Figure 1 depicts the learning components within a learning cycle and how they inform a learner profile which is subsequently used to support personalized learning.

The learner profile is built automatically on data collected about the learner, including education, interests, personality, preferences, employment, and resource accessibility. In formal courses, instructors attempt to elicit some details through student introductions, discussions, and engagement over time, and use the data to scaffold material as they teach. Similarly, an LDS collects and applies this data to personalize the learning experience and content. Personalization can take several forms:

1. Learners may start at an advanced point in the curriculum based on their existing knowledge.
2. Teaching examples and analogies may be customized to align with familiar experiences of the learner.
3. The LDS may adjust teaching strategies based on the learner’s attitude toward a topic.

These learner profile categories can be leveraged in the five components shown in Figure 1.

Figure 1.
The Learning Cycle shows activities associated with learning and their interaction with the learner profile.



Modeling the learner often involves assessing prior knowledge through pre-tests, baseline assessments, and inquiries about background experiences. This information supports instructors' and systems' ability to adapt learning content, making it relevant and effective.

The learner profile includes competencies, constraints, and a set of goals. Chief among these competencies is the learning competency that models the proficiency of the learner to achieve goals. Crafting adaptable micro-modules to personalize learning and sequencing them into a personalized pathway requires background information on the learner stored in a learner profile. The ubiquity of data opens the opportunity to shape customized learning experiences by tailoring the curriculum making it efficient compared to commonly observed approaches in today's education, such as one-size-fits-all or differentiated by group level.

Motivating the learner includes motivation to start learning a topic and motivation to endure the process to completion. The former may involve such intrinsic motivators as a need to address an immediate issue, seek out a better quality of life, or the pure joy of learning and satisfying curiosity. The latter may involve extrinsic motivators such as grades or demonstration of competency, improved by personalization of learning and supporting learner's meta-cognition. First, to support dual encoding of information through exposure to diverse modalities of interacting with the content, we envision leveraging the learner profile's tags to match appropriate content from the network of knowledge. Second, to support meta-cognition, the LDS provides immediate and specific feedback to each user to have the opportunity to improve self-learning based on the reporting that the environment captures.

Guiding the learner is the process of presenting and sequencing learning materials, achieved by using best practices such as spaced repetition, elaboration, visuals, concrete examples, and concept maps. Directed learners are guided individually by learning paths throughout the network of knowledge, ranked ordering all choices of content that meet the same learning outcomes, thus empowering the learner in selecting the depth and breadth of topics. As the motivation for learning changes for more mature learners, to progress towards exploratory learning, the LDS provides choices of content, driven by keyword matching to the learner's profile based on an updated list of keywords from the learned content, based on social networks of the learners (Andriulli, Smith, Smith, Gera, & Isenhour, 2019).

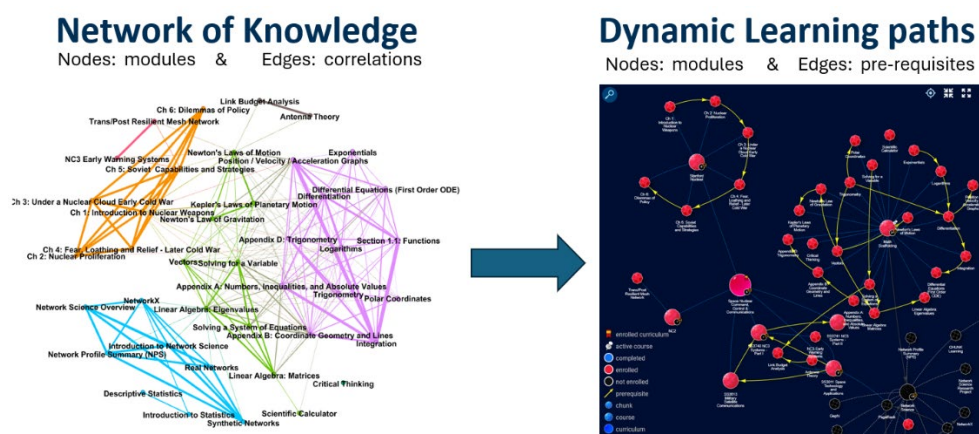
Assessing the learner often involves measuring competency, such as adaptive knowledge, skill, ability, behaviors, and characteristics of the learner. Personalized learning depends on granular data for successful agile scaffolding from micro-modules, determining the learner's current state of knowledge and gaps to meet the goals. Such assessments not only provide feedback to a learner's end state at the completion of a learning, but the learner's starting state when engaging in the next activity, guaranteeing relevant learning. Student-centered assessments that establish evidence about the learning process and validate the competencies achieved, such as formative assessments, support understanding of learning at different instances, continuously monitoring the ability to relate new information with previously acquired principles. Additionally, they provide critical feedback on the effectiveness of the learning pathways and help uncover weaknesses or gaps in understanding.

Attesting the learner involves witnessing evidence of competency and certifying the learner. Whether it manifests as a degree, certificate, testimonial, reference, or digital badge, a record of competency helps the community efficiently understand a person's proficiency in a topic. The LDS tracks and provides immediate attestation of the learner's progress to inform her decisions, while the learner progresses through the learning path. Consequently, the educational ecosystem must be dynamic, flexible, and a rich cognitive environment supported by adaptable micro-modules based on the LDS's reporting.

4. EXPERIMENTATION

This methodology based on the Learning Cycle, was piloted in a set of master-level courses in statistics and mathematics at the Naval Postgraduate School beginning in 2018. The pilot included 70 graduate students in four master-level courses which included alternative modes of engagement and alternative presenters for each topic needed to be mastered in the course. A network of knowledge was created for each course, enabling students the content to be connected to support the personalized navigation for each learner based on the learners' profiles, with additional content suggestions provided. A visual of the network of knowledge is depicted on the left of Figure 2 where nodes represent content modules, and the edges capture similarity based on content-associated tags (thicker edges represent more tags in common). The right picture of Figure 2 shows learning paths through the network of knowledge on the left, as displayed to the learners.

Figure 2.
A Sample Learning Path is displayed on the right, based on the Network of Knowledge Environment displayed on the left side of the picture.



Pre- and post-course assessments revealed several key themes. Flexibility emerged as a highly valued aspect across all courses. In the OS3604 statistics course, 90.48% of students found the flexibility in managing study time and content choice helpful or very helpful with similar benefits reported by 85.72% of students in the MA4027 mathematics course. The effectiveness of the LDS approach varied significantly by subject. In OS3604, 47.62% of students preferred the blended LDS approach, with 76.19% feeling well-prepared after completing CHUNK modules. In contrast, MA4027 had a lower preference for the LDS approach at 33.33%, with students reporting reduced preparedness.

Self-directed learning was widely encouraged across courses. Both OS3604 and MA4027 saw high usage of alternative modes of engagement for coding, as the LDS provided code in multiple coding languages for the same concept. One student from OS3604 remarked, "I liked how I could go through the material in any order at any time. The progression of the CHUNKs was logical and helped prepare me for future subjects." A student from the OS3307 advanced statistics course shared, "I loved the Matlab, Python and R scripts that she posted. The JMP videos were very helpful too." This idea was generalized to offer content in multiple modes of engaging as well, such as PDF versus Video versus PPT, for example.

The impact of course level on LDS effectiveness was evident. Introductory-level content, particularly in OS3604, benefited more from the LDS approach. In advanced topics, such as those in MA4027, while some students saw a stronger preference for traditional teaching methods, other students still found value in the new approach. One MA4027 student noted, "I prefer CHUNK over face-to-face learning due to the 'learn on your own' approach. I learn best when teaching myself and going to office hours for the things I cannot understand on my own."

The responders from OS3307 advanced statistics highlighted the challenges posed by complex subjects within the LDS framework. Despite significant time investment, only 25% of students felt well-prepared after completing CHUNKs. A student from this course commented, "It would have been a great supplement course but the face-to-face was necessary for this type of course. Which requires a hands-on lab."

These findings indicate that while LDS offers promising flexibility and encourages self-directed learning, its effectiveness varies based on subject matter and course level. As one student aptly put it, "Topics and methodology need to be much smaller in order for this type of course to work. The statistics material is extremely broad with a diverse topic set along with programming skills. CHUNK would work well with broad topics not deep dives into broad topics."

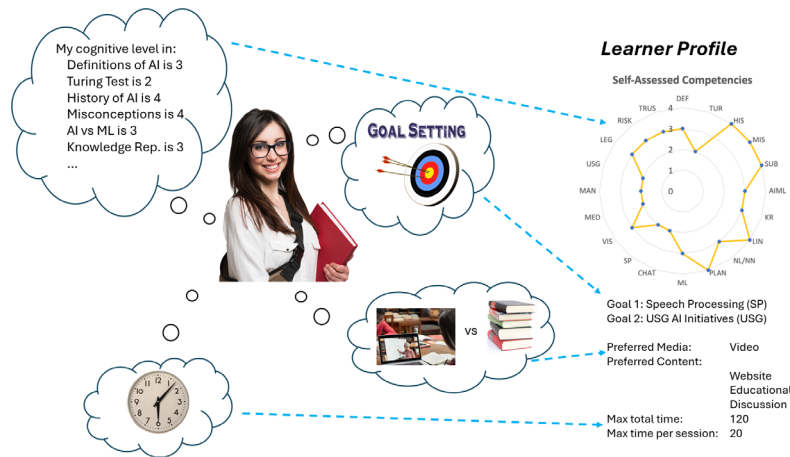
Future developments should focus on tailoring the LDS approach to specific subject needs, particularly for advanced or complex topics. The pilot demonstrates the potential of personalized educational technology while emphasizing the need for nuanced implementation strategies that consider the unique demands of different academic disciplines and levels of study.

5. SIMULATION WITH REAL DATA

Contrasting Section 4, this section introduces Learning Paths that complement structured formal classes, highlighting the benefits of using a personalized learning cycle for re-skilling each learner, rather than having all students follow the same topics as presented in Section 4.

The simulation data is based on a survey of Mochocki and Reith of 11 graduate school learners that provided their personal experiences and goal topics for an advanced AI course. We create learner profiles, as shown in Figure 4, by using the survey displayed in Figure 3, which shows just the relevant portion of the survey data used for the simulation. A complete discussion of the data can be found in (Mochocki & Reith, 2024).

Figure 3.
A sample Learner Profile is displayed on the right based on learner's metadata depicted on the left.



To create learner profiles from the questionnaire data, metadata that supports tailoring educational content to individual needs was prioritized. This includes self-assessments of background knowledge, time constraints, personal goals, and interests.

Figure 4.
A portion of the survey form used for data collection.

Cognitive Level Definitions: Use these definitions when filling out the table below:

Cognitive Level 1: A person at this level has very little understanding of the topic and is not familiar with normal terminology, acronyms, or how the concepts fit together.

Cognitive Level 2: A person at this level is familiar with the acronyms and the terminology in this topic area but is not able to meaningfully contribute to conversations in this area.

Cognitive Level 3: A person at this level is familiar with the acronyms and terminology related to this topic and can contribute to conversations with others who are also familiar with this topic. They are prepared to read technical papers and watch scholastic lectures in this area, even if they do not understand everything they read or hear the first time or need to do additional research to aid in their understanding of some advanced concepts.

Cognitive Level 4: A person at this level can understand most materials on this topic, including those that may be technical in nature.

How would you rate your cognitive level (CL) on each of these 20 topics according to the provided scale? Also, indicate **two** goal topics you would choose for a PLP? (mark Y for goal nodes, N otherwise)

Topic	CL	Goal?	Topic	CL	Goal?
Definitions of AI and Intelligence		Y N	Machine Learning in general		Y N
Turing Test and its Improvements		Y N	Chatbots for user interaction on simple tasks		Y N
History of AI		Y N	Speech processing		Y N
Misconceptions about AI		Y N	Computer vision		Y N
Main subareas of AI		Y N	AI in medicine		Y N
AI versus Machine Learning		Y N	AI management roles		Y N
Knowledge Representation		Y N	U.S. Government AI initiatives		Y N
Linear Models		Y N	Legal issues in AI		Y N
Nonlinear models and neural networks		Y N	Risks of AI		Y N
Planning and Search		Y N	Developing trust in AI		Y N

Estimate your preferred media type? (circle 1): Video, Written, No Preference

Estimate your preferred content type rank ordered from 1-9? (1 indicates most preferred, 9 least preferred):

Research ____ Educational ____ Do it Yourself ____ Lecture ____
 Website ____ News Article ____ PowerPoint ____ Textbook Excerpt ____
 Discussion ____

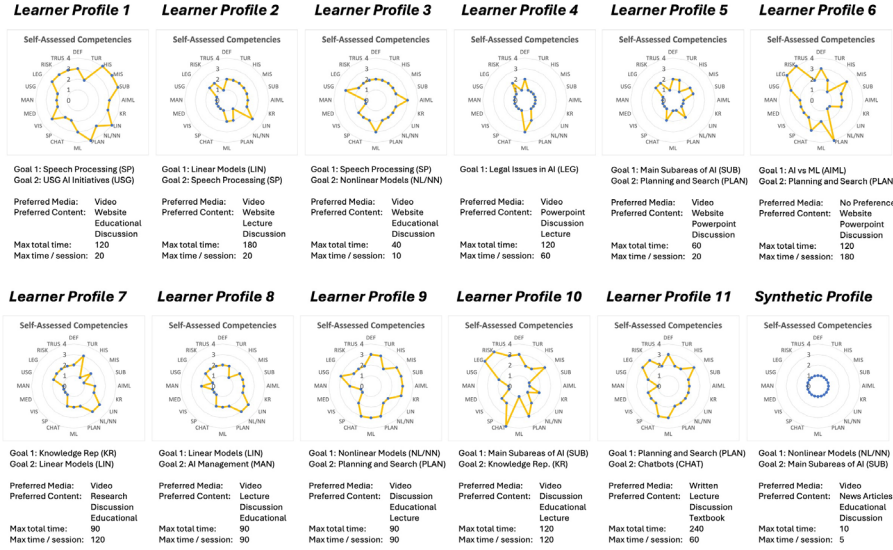
Estimate your max time available for committing to completing a PLP (in minutes): _____

Estimate your max time available per learning session (in minutes): _____

Please provide any media types, content types, or topics not mentioned above that you might be interested in:

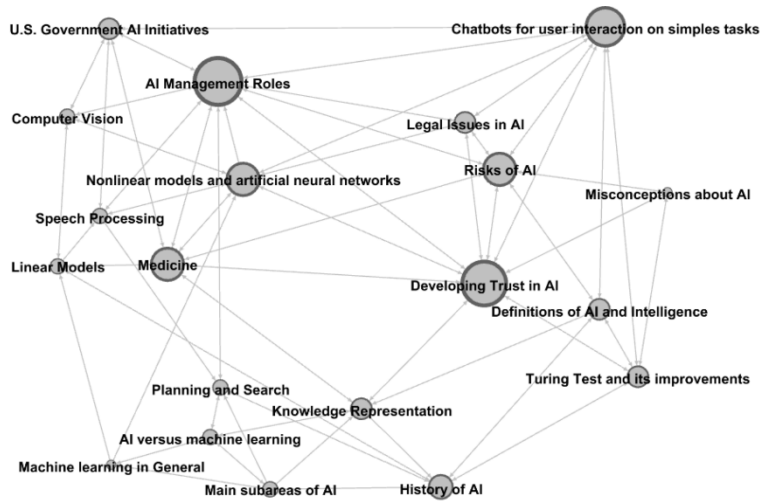
The learner profile data collected using the survey of Figure 4 includes 11 users and their metadata, along with one synthetic profile designed to test a corner case (Mochocki & Reith, 2024) displayed cumulatively in Figure 5.

Figure 5.
The 11 learner profiles and one synthetic profile used in our simulation.



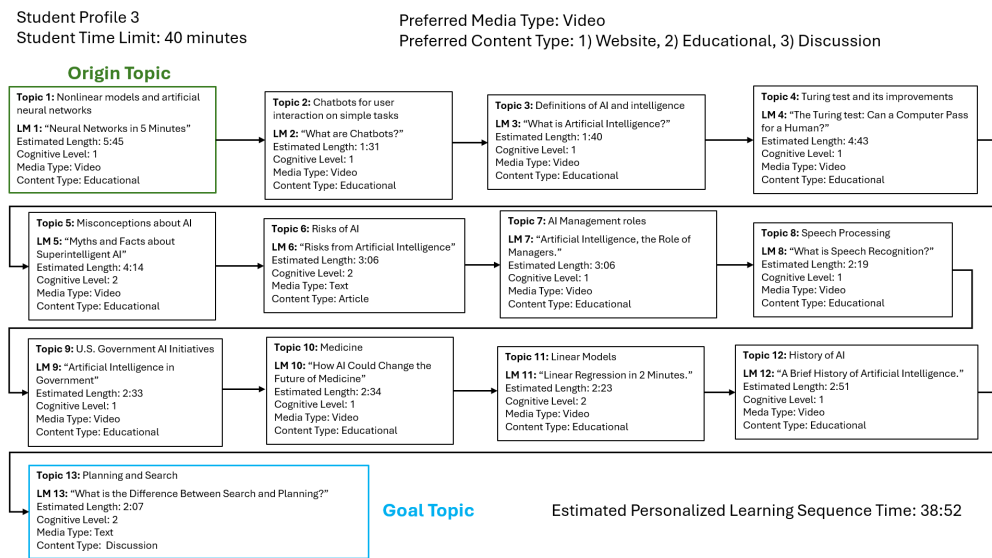
The network of knowledge used for this experiment, is introduced in Figure 6, where nodes represent the AI topics depicted in Figure 4, and the directed arcs capture prerequisite relationships. Double-arrow arcs indicate correlations between topics. The nodes are sized by their number of relationships, thus identifying commonly needed pre-requisites.

Figure 6.
The network of knowledge of the AI topics from Figure 3 (the nodes are the topics, and the arcs capture topical relationships between them).



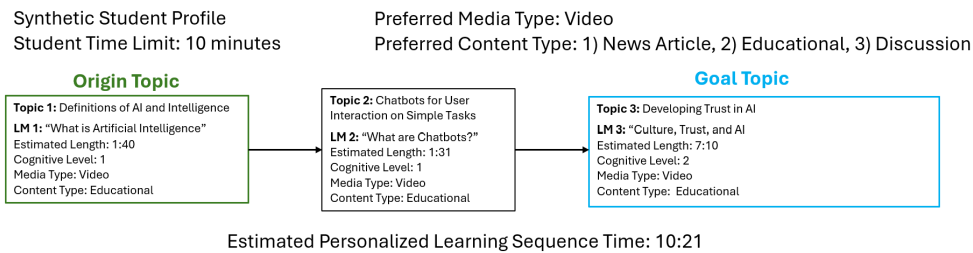
In Figure 7, we display a sample learning path for Student Profile 3 through the network shown in Figure 6. It provides content based on the learner's profile of Student 3, in order to meet the learning goal of the profile. In this approach, learning materials are scored according to whether they match the student's cognitive level for that topic, if they match the student's media preference (video vs written) and how well they match the student's content preferences (DIY, websites, etc). The completion time for learning paths is the sum of the learning materials' time on the path.

Figure 7.
A sample learning path matching the tags of Student Profile 3.



Since students provided their total available time in the survey, the LDS aim to meet it if possible. The Synthetic student profile has 10 minutes of available time to learn, and the shortest path from origin topic to goal topic is 10 minutes and 21 seconds as shown in Figure 8. And so there is no solution for this student, however, the suggested path is very close the requested one and can be shown as an option for the student's decision. The synthetic profile demonstrates that the expectations cannot always be met, but a near-optimal path with its associated duration can still be proposed.

Figure 8.
A sample "best fit" learning path when there is no solution due to time constraint.



6. CONCLUSION AND DISCUSSION

This work addresses a very important question that whether personalized and individualized learning can occur effectively and efficiently in a learning environment that benefits from advances in technology. The introduced model is centered around the learning cycle of a learner's profile to support personalized learning paths through a network of knowledge, concluding with assessing the competency of the learner. The learning science motivation for this approach is presented, building on the network science framework for personalized education, which uses learning paths of micro-modules derived from a network of knowledge (Gera et al., 2019).

Recommendations for learning paths and assessments can be personalized based on the learner's profile, with content tailored to existing competencies and interests. Results from pilot studies at the Naval Postgraduate School demonstrate the benefits of this model. We complement this study by present real learner profiles and simulations showcasing the creation of personalized learning paths based on these profiles are included, highlighting the possibilities this approach offers.

Future explorations could focus on incorporating Artificial Intelligence (AI) to leverage emerging technologies. In education design, AI can support both the network curators and learners, since knowledge identification, curation, and uploading is time-consuming. For example, an automated way of updating the network of knowledge's learning materials creates a dynamic (vice static) network construct would enable a collaborative growth of the knowledge (Singh & Gera, 2024). Additionally, AI-agents could complement the current learning experience and work towards shortening the time required for students to learn the same skill efficiently (Mochocki et al., 2024).

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Chapter # 28

FOSTERING SCIENTIFIC THINKING IN PRIMARY STUDENTS THROUGH INVESTIGATIVE ENVIRONMENT

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ABSTRACT

The Agenda 2030 objectives highlight the need to engage students in STEM (Science, Technology, Engineering, and Mathematics) to support ecological and cultural transitions. Understanding students' scientific thinking involves examining their social, cultural, and environmental contexts. Inquiry-based learning is an effective teaching strategy that promotes exploration and develops scientific reasoning. This work presents preliminary findings from a case study testing innovative teaching methods to inspire primary school students in STEM. In the first phase, a class of final-year primary students participated in a hands-on physics activity using an inquiry-based approach. Observations indicated that the activity improved reasoning flexibility, encouraged collaborative learning, and increased motivation and engagement.

Keywords: STEM, scientific thinking, inquiry-based, scaffolding, collaborative learning.

1. INTRODUCTION

The international debate on education in recent years has certainly paid a lot of attention to the importance of promoting STEM (Science, Technology, Engineering, and Mathematics) disciplines in schools from the early years of the education path (ONU Agenda 2030; European Commission, 2018).

Science education is a fundamental aspect in the development of both disciplinary and transversal skills (such as creativity, critical thinking, and reasoning skills) that can promote citizenship skills (i.e. social, economic and environmental skills) (Edwards-Schachter, García-Granero, Sánchez-Barrioluengo, Quesada-Pineda, & Amara, 2015; Amos & Levinson, 2019; Karamustafaoğlu & Pektaş, 2023). The new generations will increasingly live with scientific discoveries and related technological transformations. Therefore, thinking about learning paths that respond to emerging educational needs is essential. Students must develop skills to participate in discourses that incorporate scientific concepts and be able to evaluate the argumentations involved critically.

It becomes fundamental to assume a theoretical and methodological perspective on which to base the learning paths of STEM disciplines. This will support the development of scientific thinking and the capacity for hypothetico-deductive, inductive, and analogical reasoning, increasing the ability to use critical thinking to understand reality.

The socio-constructivist perspective can represent a valid theoretical framework of reference as it considers learning a knowledge construction process in which the learner plays an active and creative role (Fleer, 2021). This educational approach favours participatory forms of learning, stimulating children's initiative and sharing and collaborating with peers.

Interaction becomes central in the learning process, both with respect to the relationship between peers and the relationship between teacher and students.

The role of the teacher in this process is to provide a "support structure" or "scaffolding", which sustains the children's learning process by helping them to acquire a higher level of skills than they initially possessed (Bruner, 1976; 1990; Belland, 2017; Hsu, Lai, & Hsu, 2015; Lee & Tee, 2021; Shin, Brush, & Glazewski, 2020) and stimulate reflection, reasoning and argumentation through innovative teaching strategies. Among these, the "inquiry-based learning" approach can represent a suitable methodology for facilitating and encouraging the development of scientific thinking in children, as it places inquiry at the center of the learning process (Worth & Grollman, 2003; Krogh & Morehouse, 2020). The teacher encourages free exploration and experimentation by the children of a particular scientific phenomenon, invites them to ask questions and share them with the group; the teacher participates in the process of building knowledge, welcomes their reflections and helps them structure more advanced and complex forms of argumentation.

2. THE INQUIRY-BASED APPROACH

The term "inquiry" precisely describes the investigation, the action that characterises the scientist's work. The scientist investigates reality to understand its phenomenology, identify causes, and find relationships. His action is concrete and is articulated in continuous training to observe by experimenting with techniques and methodologies that make his investigation increasingly accurate and precise.

Referring to the model proposed by Worth & Grollman (2003), learning based on inquiry is characterised by different phases. Initially, children explore the phenomenon and the materials proposed for exploration. They put themselves to the test by experimenting, through play, what they can do and how they can do it. At the same time, they formalise their exploration by formulating questions and freely sharing ideas among peers and teachers. Questions are the antechamber of the argumentation process. They induce reflection and planning of the exploratory activity. This phase alternates with a more guided and structured one by the teacher. Inquiry is always at the centre of the action. Still, the process gradually develops to enable the child to try more targeted explorations that allow him to make predictions, plan results, and collect and record even simple data.

2.1. The Role of the Teacher in Learning Processes Based on Inquiry

The teacher takes on the role of mediator in the process of facilitating inquiry and promoting it as a learning style in the child through scaffolding processes (Brown & Palincsar, 1989; Cobb, Yackel, & Wood, 1992; Collins, Brown, and Newman, 1987; Strat, Henriksen & Jegstad, 2024). The teacher supports the child's instinctive predisposition to inquiry. The teacher does not guide the child to acquire knowledge but to construct knowledge according to the scientist's own style.

"Scaffolding" is a metaphor used to explain the role of the adult in child-centred education. Introduced by Bruner and colleagues in 1976, this concept illustrates how an adult supports and guides a child during an activity. Rather than simplifying the task, the adult assists the child in developing skills beyond their capabilities through shared interpersonal interactions. Acting as a scaffold, the adult offers support, sustenance, and encouragement as the child navigates through the complexities of the activity.

In this approach, the adult doesn't just teach the child how to complete the activity. Instead, they engage with the child in diverse ways, responding to their actions and thoughts. By complementing the child's efforts, the adult provides dynamic support that encourages the child's interest, keeps the activity's complexity in focus, aligns with the activity's objectives, guides the child in learning proper actions, and assists the child in reflecting on their thought process and regulating the activity.

According to Bruner and colleagues, the task is not simplified, but the child is not alone in performing it. This allows the child to develop competencies above individual performance level but shared on the interpersonal plane. The adult acts as a scaffold, an existing structure that supports, sustains, and promotes the child in climbing up the complexities of the ongoing situation.

The adult does not simply teach the child how to perform an activity but interacts with the child in very different ways, each sensitive to the child's actions and thoughts (Asy'ari, Ikhsan, & Muhali, 2019; Cruz-Guzmán, García-Carmona, & Criado, 2020). By complementing the child's initiatives, the adult offers dynamic support that:

- promotes the child's interest in the activity;
- maintains the complexity of the activity in sight;
- is oriented towards the intended objective of the activity;
- guides the child to learn how to act properly;
- supports the child in reflecting upon her/his thinking process and regulating the activity.

2.2. The Process of Thinking

In inquiry-based teaching, the emphasis placed on building an idea is a fundamental element in promoting meaningful and lasting learning. This teaching approach stands out because, instead of focusing solely on the correctness of answers, it values the path that leads to the formation of ideas, promoting creative thinking and the development of argumentation skills (Kuhn, Black, Keselman, & Kaplan, 2000).

In a traditional educational context, children often learn to search for the "right" answer to meet teachers' expectations. However, this method can limit intellectual exploration and inhibit children's natural curiosity. On the contrary, the inquiry-based approach encourages children to see the learning process as a continuous exploration, where each hypothesis formulated is considered valuable, regardless of its outcome. This allows children to develop a positive attitude towards science and knowledge since they feel free to experiment, make mistakes and correct themselves without fearing judgment.

Allowing children to confirm or refute their hypotheses, often unique and deeply personal, is essential for developing critical thinking. Testing their ideas strengthens their reasoning skills and helps them understand that knowledge is a constantly evolving construct. Valuing these hypotheses, therefore, becomes the first step in ensuring that children develop confidence in their cognitive abilities and consider science a field open to investigation and discovery.

In this context, the teacher's role is crucial. Instead of providing immediate answers, the teacher should adopt a dialogic approach, responding to children's questions with further questions that stimulate reflection. The teacher should encourage children to search for answers within themselves, formulate new hypotheses, and explore different possibilities. In this way, critical thinking is activated and nourished as children learn to evaluate and reconsider their ideas, developing greater intellectual autonomy (Lee & Tee, 2021).

Furthermore, the inquiry-based approach encourages peer collaboration and comparison, where ideas are discussed and argued collectively. This improves children's communication skills and prepares them to work in teams, consider different perspectives, and build knowledge cooperatively. In an environment that values idea-building, children learn that the learning process is not linear but a journey whole of exploration, reflection, and discovery (Chen, 2021).

3. DEVELOP SCIENTIFIC THINKING THROUGH EMBODIED INVESTIGATION

According to Jonassen, Marra, and Palmer (2004), learning environments that are designed according to a socio-constructivist perspective differ from traditional teaching approaches because they offer multiple representations of reality that reflect the complexity of the world; they encourage active knowledge construction by students, propose authentic and meaningful tasks, connected to children's experience and the real world; they encourage reflection, reasoning and collaborative forms of learning, where negotiation rather than competition is encouraged.

The learning environment should be built to stimulate investigation and encourage children's active participation and direct experience. Traditionally, the frontal methods of teaching have resulted in learning practices in which communication in the classroom is based on sitting students, where the teacher frames the topic and sets the pace of the lessons, encouraging students to express their opinions and ask questions, but always remaining in a static position. According to this view, using movement and bodily experience is not considered a factor connected to the learning process. Thought processes are closely linked to cognitive processes but less to sensorimotor processes. It follows that teaching does not encourage children's movement in the classroom and does not incorporate it into the learning experience, instead supporting the importance of maintaining a sitting position in class, considered a good indicator of the ability to concentrate and focus on the task.

However, the studies that have developed the theme of embodied cognition undermine this traditional conception, highlighting the central value of bodily experience in the process of building knowledge. Based on the theoretical framework of bodily cognition, action and perception are inextricably linked: the sensorimotor experiences derived from the environment contribute to grounding the cognitive processes (Glenberg, Witt, & Metcalfe, 2013; Danish, Enyedy, Saleh, & Humburg, 2020; Dove, 2022).

Therefore, the thinking process can be built starting from children's concrete experiences in learning contexts since cognitive aspects and sensorimotor processing are closely linked (Wilson, 2002). Scientific evidence has highlighted a correlation between activities such as observation, simulation of other people's gestures and imitation and the activation of brain areas central to learning (Rizzolatti & Craighero, 2004; Meister et al., 2003). For example, some studies highlight how attention and memory improve when using hands are associated with learning (Weidler & Abrams, 2014). Other studies support evidence that highlights the positive effects of movement and the use of gestures in learning mathematics (Riley, Lubans, Holmes, & Morgan, 2016).

This evidence underlines how learning processes can be supported by practical experience and how theoretical STEM concepts can be understood more easily by designing learning environments that involve experimentation through the use of the body and movement (Schmidt et al 2019).

4. OBJECTIVES

In this work, we will present some preliminary data from a case study that aims to experiment with innovative pedagogical models to stimulate the interest of children in primary school in scientific reasoning of STEM disciplines. The first phase of the project involved a class of pupils attending the last year of primary school who participated in an educational experimentation activity on learning physics based on an inquiry-based learning approach.

5. METHODS

A fifth class of primary school (composed of 10 children) participated in the investigation. The activity proposed to the children concerned the motion in one dimension (introduction to the study of kinematics in Physics, description of motion and its patterns) and took place in 2 meetings for at least 3 hours. These features sampled what was needed for conducting a case-study research design (Creswell & Poth, 2017).

The activity was prepared together with the teacher according to an inquiry-based approach and was characterised by the following aspects:

- Structuring student-centered learning environments;
- Learning process based on active learning;
- Centrality of student participation to encourage a process of knowledge construction.

These three aspects were shaped using the Investigative Science Learning Environment (ISLE, Etkina, Brookes, & Planinsic, 2019) approach. The ISLE process guarantees that it will fulfil the aspects we require for our activity design (Brookes, Etkina, & Planinsic, 2020). This is a crucial methodological point in conducting our research: the content design has to be thought in a well-defined disciplinary framework to ensure we achieve research outcomes. An ISLE-based learning activity is an authentic inquiry experience where children learn Physics by mirroring scientists' practices (Etkina et al., 2019; Brookes et al., 2020). In making science, children are engaged in scientific cognitive processes: the same ones they need to develop scientific abilities (Etkina et al., 2006). Furthermore, the teaching/learning ISLE sequence is designed in order to activate and connect different brain areas, providing a complete cognitive learning cycle (Etkina et al., 2019; Zull, 2004; Weidler & Abrams, 2014), enhancing embodied cognition (Schmidt et al 2019; Gregorcic, Planinsic, & Etkina, 2017).

The children's learning experiences were video recorded; then, all the videos were transcribed, and the transcriptions were used as a starting point for the analysis's insight. The transcribed dialogues have been framed into clustering of discourse sequences, which should recognise a particular structure, depicted using vignettes (Skilling & Stylianides, 2020), like snapshots from the video frames.

The analysis of the vignettes highlighted the learning and thinking processes that the children developed during the teaching experience. The purpose of the analysis of the contents of the vignettes was to identify significant aspects of the process of scientific thought formation, linking them to the participation processes and the structure of the learning environment. Specifically, the following indicators were considered: the different levels in the scaffolding process, the construction phases of the scientific thinking process (in terms of reasoning), and the emotional/motivational aspects (in terms of embodied engagement).

6. RESULTS

This section will highlight the main results analysing our video transcription files. The vignettes presented here focus on representative features of the entire scenario in the classroom activity. We underpinned the main processes we investigated for each selected vignette in this study. We selected the ones who led us to the processes involved, from the teacher's point of view, examining the scaffolding strategy and the children's standpoint in reasoning and embodying epistemic practices.

In Vignette #1 (Figure 1), the activity involves pulling a ball along a defined path, marking its progress with sand packets that fall as the ball moves. At the same time, a metronome pulses at 60 BPM on the interactive whiteboard. Scaffolding is provided through procedural tips for effectively setting up and executing the activity. Throughout the activity, the teacher actively engages students in reasoning processes. This is done by guiding them to observe and analyse the patterns that emerge as the ball moves along the path, such as the timing of the sand packets falling or the rhythm set by the metronome.

All students are actively involved in the learning experience, playing various roles that allow them to embody the activity.

The Vignette #2 (Figure 2) allows us to emphasise the richness of the process. From the scaffolding strategy, the teacher continues to encourage children's engagement through procedural scaffolding, guiding how to pull the ball, beat time, and observe patterns. As students become more familiar with the task, they change their roles, and thus perspectives. Over time, the scaffolding is gradually reduced; children take more responsibility and develop self-empowerment in conducting the activity independently. This fosters their autonomy and confidence in the activity development. During this time, reasoning processes are activated: children recognise patterns and make cognitive connections, observing space-time relationships between the speed of the ball (slow or fast) and the number of sand packets falling (more or fewer). The teacher reinforces these conceptual connections through repetition and variation.

Figure 1.

Vignette #1: starting activity, finding patterns.



As students progress, their reasoning becomes more sophisticated. This happens while children are engaged in a highly physical learning experience involving movements such as pulling the ball, clapping hands, stepping feet, and repeating time aloud. This "embodied measurement" helps students internalise abstract concepts through physical actions. As they collaborate and exchange roles, students experience different facets of the activity, enhancing their understanding through sensory and kinesthetic experiences. The process culminates in developing an "embodied technique," where students perform the activity with confidence and fluency.

In Vignette #3 (Figure 3), a new process step starts. The teacher provides procedural recommendations to guide children towards articulating their observations verbally. This begins with prompting students to describe their actions, the materials they are using, and the outcomes they are observing. The teacher also facilitates group discussions, encouraging students to build on each other's ideas. Reflection is activated as part of the reasoning process. As students speak, their gestures and movements complete their words, furnishing a fuller profiling of their cognitive loading of new information. This physical engagement is instrumental in making abstract ideas more available, as it helps to anchor their verbal representations in concrete, sensory experiences, according to the experiential learning cycle (Zull, 2004). Children use their hands to illustrate the movement of an object, point to specific facets of their activity, or mimic actions that embody the concepts they are discussing.

Figure 2.
Vignette #2: repeating trials.



The Vignette #4 (Figure 4) exhibits the time for the visualisation process of drawing sketches. This activity is designed to enhance student's ability to represent their observations through drawing, blending visual thinking with verbal and physical engagement to create coherent representations of real-world phenomena. The teacher provides reinforcement to guide children towards creating pictorial representations of their experience. Initially, the teacher helps students translate their observations into visual layout, improving their capability to communicate complex ideas through simple sketches. Drawing and sharing these visual representations activates reasoning by encouraging students to conceptualise a coherent depiction of real scenario.

Figure 3.
Vignette #3: verbalisation time.



Vignette #5 (Figure 5) shows the activity designed to evaluate the consistency between different types of representations - verbal descriptions and sketches - by engaging students in collaborative reflection. The teacher supports students in evaluating the consistency between their verbal and pictorial representations. The working group is now fundamental: this peer-to-peer evaluation enhances understanding and promotes active listening and productive feedback. Through this evaluation process, students learn to refine their thinking and improve their representations. The embodied aspect of this activity involves students working in groups, standing around the whiteboard or large paper surfaces, actively pointing, gesturing, and using their bodies to draw attention to specific elements of their sketches or verbal explanations. As they discuss, they may use hand movements to trace the path of objects, point out differences, or highlight particular areas of the drawing. words and

sketches, students enhance their critical thinking and metacognitive skills, while the creation of a shared artifact reinforces collaboration, communication, and the integration of diverse perspectives into a unified representation.

Figure 4.
Vignette #4: drawing time.



Vignette #6 (Figure 6) shows the last scenario of the activity done. This activity stage focuses on communicating using a combination of verbal descriptions and pictorial representations. The teacher promotes time for storytelling and group discussions. Each group presents their representations. The teacher also encourages active participation from all students by prompting them to listen carefully, and provide constructive feedback. Verbalization becomes a key tool for the reasoning process. As children describe their sketches using spoken language, they must clarify their thinking and make explicit the connections between their visual and verbal representations. This process of verbalization helps them articulate their understanding, find gaps in their reasoning, and refine their interpretations based on group feedback.

Through dialogue, students justify their choices and explain the reasoning behind their representations. Promoting deeper engagement with the material encourages them to think critically about how different forms of representation can effectively convey meaning. For instance, they may discuss why a certain shape represents a concept or how a particular color in the sketch conveys a specific idea. These discussions help students internalise that representations are passive displays and active tools for communicating complex concepts.

Figure 5.
Vignette #5: group discussion time.



Gestures play a significant role in complementing verbal explanations and enriching overall communication. When students showcase their sketches, they employ expressive hand movements, body language, and facial cues to emphasize particular elements of their drawings, direct the audience's focus to specific details, and communicate subtleties that verbal expression alone may not fully convey. Combining spoken explanations, visual illustrations, and physical gestures helps all students better understand and connect with the information. When students discuss their ideas in a group, they improve their understanding and add to what the whole class knows. During each presentation, students have the opportunity to engage in reflection, compare their approaches, consider alternative perspectives, and refine their thinking based on the insights provided by their peers.

Figure 6.
Vignette #6: communication time.



5. DISCUSSION AND CONCLUSION

This study highlights how innovative teaching methods can enhance scientific reasoning in STEM fields, especially through embodied, inquiry-based learning. The activities demonstrate the benefits of integrating physical experiences into learning to boost cognitive development, conceptual understanding, and engagement in young learners.

The learning environment based on the ISLE framework (Etkina et al., 2019) effectively balanced scaffolding and independence. This approach allowed students to shift between experiential learning and conceptual reasoning. Students gained a multi-modal understanding of physical concepts through activities like pulling the ball, observing patterns, and sketching their observations. These results support research on the link between sensorimotor processes and cognitive functions (Glenberg et al., 2013; Schmidt et al., 2019).

This research aims to provide insights into two key points of interest deserving of in-depth exploration: the development of scientific thinking through embodied practices and the scaffolding and collaboration processes as catalysts for learning.

Concerning the development of scientific thinking, this study tries to contribute to validating how embodied cognition enhances learning. Physical activities like handling objects and gestures helped students connect abstract concepts to real-world phenomena. This was evident during "embodied measurement" and "drawing time," where students internalised concepts through sensory interactions. During group discussions, children used gestures and actions to support their explanations, reinforcing that physical movement enhances verbal and visual communication. These strategies fostered metacognitive skills as

students reflected on their reasoning and adapted explanations based on peer feedback. Integrating movement into learning challenges traditional classroom methods, providing evidence of the benefits of combining cognitive and bodily engagement. (Rizzolatti & Craighero, 2004; Weidler & Abrams, 2014).

The teacher's scaffolding strategies were crucial in building student autonomy. Initially, they offered procedural guidance and encouraged role-switching, ensuring active participation and diverse perspectives. As students familiarised themselves with the task, support was gradually reduced, promoting independence and confidence. This withdrawal of support aligns with socio-constructivist principles of active participation and knowledge co-construction (Jonassen et al., 2004). Indeed, Collaboration has become an essential aspect of the learning process. Engaging in group discussions and peer evaluations enabled students to practice negotiation and collaborative problem-solving, enhancing the social aspect of scientific reasoning. These collaborative activities helped students sharpen their individual insights while also adding to the class's collective knowledge. This supports previous research highlighting how collaboration fosters critical thinking and deeper understanding. (Brookes et al., 2020).

These two aspects present some actionable implications for STEM education. The first concerns integrating embodied learning as an accessibility tool for content-driven abstract concepts in primary education. The second concerns encouraging students to express their understanding through multiple representations as a reasoning tool for critical thinking development. The last concerns enhancing understanding and fostering a collaborative learning culture through group work and peer feedback in the context of dynamic scaffolding teacher support.

This study highlights the value of innovative, embodied, and inquiry-based approaches to STEM education. By linking sensorimotor experiences to cognitive processes, fostering collaboration, and emphasising multi-modal communication, the learning environment successfully supports the development of scientific reasoning in young learners. These findings reinforce the importance of designing interactive, student-centred activities that reflect the complexity of real-world phenomena while making learning both meaningful and engaging. Future research could expand on this preliminary work by exploring the long-term impact of embodied learning approaches across diverse STEM topics and evaluating their scalability in larger classroom settings.

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Chapter # 29

TOWARDS A FRAMEWORK TO SUPPORT NOVICE TEACHERS IN RURAL AREAS: IMPLICATIONS FOR BLENDED PROFESSIONAL DEVELOPMENT INITIATIVES

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ABSTRACT

Research indicates that teacher professional development significantly influences teaching practice. The widespread adoption of online and blended modes of professional development that occurred in response to the COVID-19 pandemic was expected to enhance access to professional development for teachers in remote and rural areas of South Africa. However, research on the use of blended professional development in these settings remains limited. This study addresses this gap by employing a qualitative approach to examine the key components of a blended teacher professional development intervention in a rural area. Data was collected using classroom observations, interviews, and field notes and was analysed thematically. The study identified several components that contributed to the effectiveness of the intervention: sustainability, content focus, coherent, access to digital tools, active engagement, longer duration, individual support, and collaboration. The study also underscored the importance of facilitators of blended professional development possessing Technological Pedagogical Content Knowledge (TPCK) competency.

Keywords: teacher professional development, blended professional development, novice teachers, rural areas, technological pedagogical content knowledge (TPCK).

1. INTRODUCTION AND BACKGROUND

Professional development has been shown to play a significant role in improving teaching practices and, ultimately, learner performance (Darling-Hammond, Hyster, & Gardner, 2017). As teachers engage with new knowledge and skills related to the subject content and appropriate pedagogical practices, they reflect on and revise their teaching practice (Darling-Hammond et al., 2017). Mushayikwa and Lubben (2009) argue that, for professional development to be effective, it should incorporate four components: the acquisition and enhancement of content knowledge and pedagogical content knowledge; active learning; coherence; and collaboration amongst teachers. Over the years, this conceptualisation has gained widespread acceptance among researchers (see Darling-Hammond et al., 2017; Desimone, 2009; Patton, Parker, & Tannehill, 2015). For professional development to be coherent, Kaino et al. (2015) explains that it should be aligned to the needs and interests of teachers and, ultimately, to the improvement of learners' performance. This aspect is important since teachers engage in professional development to improve the achievement of their learners (Letloenyane & Jita, 2020). Bayar (2014) adds that professional development should also be aligned to the needs and interests of learners, as well as the goals of the national education authorities and schools. Researchers contend that professional development can be effective if it is of longer and continuous duration

(Darling-Hammond et al., 2017; Desimone, 2009; Patton et al., 2015). ‘Longer’ duration entails at least 20 hours of contact time (Desimone, 2009). However, in rural contexts in South Africa, geographical, financial, and time constraints present challenges to incorporating these components into teacher professional development.

2. LITERATURE REVIEW

Researchers agree that traditional approaches to professional development that use face-to-face, top-down, theory-driven workshops that are not tailored to the needs and teaching contexts of participants typically involve little or no collaboration between participants and result in passive learning (Little, 1993; Guskey, 2002; Darling-Hammond et al., 2017). This approach to professional development was designed to meet the systemic needs of the education authorities and seldom considered the variable contexts in which educators actually teach. In contrast, current professional development initiatives place greater emphasis on the needs of individual teachers and employ pedagogies such as learning on the job through lesson studies (Lewis, Perry, Foster, Hurd, & Fisher, 2011), coaching and mentoring (Kraft, Blazar, & Hogan, 2018), and professional learning communities (PLCs) (Dufour, 2004). There has also been a shift towards active and collaborative learning through peer observation and coaching.

These traditional and modern models of professional development have relied on face-to-face interaction. This modality presents a particular set of challenges which are often exacerbated in rural settings. Transport costs and time constraints may be amplified because of the greater distances teachers must travel to gather at a professional development workshop, and human capital may be a constraint as there may be fewer teachers teaching the same subject. A blended modality, which combines face-to-face and online modes, may be a more practical approach for professional development in rural settings.

Online professional development is characterised by using available digital technologies to promote teacher development. Online sessions may incorporate the same components that are used in face-to-face or traditional professional development, e.g. content focus, coherence, collaboration, and active learning (Powell & Bodur, 2019). Powell and Bodur (2019) explain that active learning is characterised by the completion of authentic tasks and reflection, while coherence is determined by the relevance and usefulness of the professional development content. The intersection of technology with content, pedagogy, and knowledge – technological pedagogical content knowledge (TPCK) – differentiates online professional development. TPCK refers to a teacher’s knowledge and skill to be able to use technology effectively in their teaching to enhance learning (Kulaksız & Karaca, 2023). It is important that the designers and facilitators of online or blended professional development interventions have a high level of TPCK competence to enable them to effectively transform content knowledge – rather than simply transferring it to a digital online format – to facilitate meaningful changes in teaching practice (Powell & Bodur, 2019). As professional development may be offered online using synchronous or asynchronous modalities, designers and facilitators also require the competence to design interventions that are effective for each of these approaches.

While online professional development may address some of the challenges that arise with face-to-face interventions, it does present its own set of challenges. One of the factors that may constrain the effectiveness of an online professional development intervention, regardless of context, is resistance on the part of teachers towards the use of digital technology (Dille & Røkenes, 2021). Teachers may experience negative attitudes toward the use of digital technology if they do not have adequate competence and experience using the

technology to be able to engage in online professional development activities without experiencing barriers (Belland, Burdo, & Gu, 2015; Tsiotakis & Jimoyiannis, 2016). Belland et al. (2015) add that teachers may also have a negative view of using online modalities if they are not familiar with interacting asynchronously with their fellow teachers. In synchronous online professional development sessions, participants tend to turn off their cameras. While the reason for this may be to reduce bandwidth use and visual distractions, Gherheş, Stoian, Fărcaşiu, and Stanici (2021) argue that this behaviour should be investigated to determine whether participants engage as fully and effectively in a synchronous activity when their cameras are turned off. While Gherheş et al.'s (2021) study focused on students, this consideration is also relevant to teacher professional development activities that are conducted online.

Hunt-Barron, Tracy, Howell, and Kaminski (2015) investigated the challenges faced by teachers in rural areas when new technologies were introduced to enable online professional development. They found that teachers felt overburdened and were unable to cope with additional tasks, such as posting a reflection online. These findings correspond with those of Tsiotakis and Jimoyiannis (2016), who also found that teachers' lack of personal time influenced their participation in online activities. This is mainly because online teacher professional development is usually scheduled outside of teachers' working hours. Teachers at rural South African schools have been found to carry a heavier workload due to the shortage of teachers in these areas (Masinire, 2015). Hunt-Barron et al. (2015) also found that teachers who engaged in online professional development were uncomfortable with the lack of privacy when they were required to post, share ideas, or ask for help in a public online space. Lastly, they found that teachers frequently experienced challenges with network coverage and connectivity, hindering their access to professional development (Hunt-Barron et al., 2015). Mukuna and Aloka (2020) found that lack of electricity, poor network coverage, and the cost of data were some of the factors that constrained online learning in rural areas in South Africa. While lack of electricity and poor network coverage are issues beyond the control of any professional development programme, the issue of cost of data can be addressed. Research shows that lack of data is a barrier that negatively affects the level of engagement in any online activity, regardless of the context (Campbell, 2019). Thus, teachers must be provided with adequate resources, such as data bundles and technological learning devices, to enable access to online opportunities for professional development (Mukuna & Aloka, 2020).

To overcome the challenges of each of the modes of professional development discussed above, Palvia et al. (2018) proposes that the strengths of the online and face-to-face modes be blended to enhance professional development. Several models for blended teacher professional development have been put forward. For example, Philipsen, Tondeur, Pareja Roblin, Vanslambrouck, and Zhu (2019) developed a conceptual framework that identifies important components of teacher professional development for online and blended learning. Wittmann and Olivier (2021) developed a model for blended teacher professional development that considers the experience of teachers, as well as their individual differences, in terms of learning needs, preferences, and styles. However, none of these models consider the contextual aspect of teacher professional development – for example, the rural context. Consideration of context is crucial to ensure that teacher professional development initiatives are relevant, effective, and sustainable. These models are not easily customised to different contexts, and thus are not appropriate or useful in rural contexts, which have unique challenges.

The aim of this study was to determine the key components that are needed to ensure that blended professional development initiatives targeting novice teachers in rural contexts are effective. This was articulated as the research question: *What are the critical components of effective blended professional development initiatives for novice teachers in rural areas?*

3. METHODOLOGY

This study was part of a larger research project that facilitated a professional development intervention for 13 Physical Science teachers from a circuit of rural schools in the Mpumalanga province of South Africa. The purpose of the intervention was to enhance the teachers' subject content knowledge (SCK) and pedagogical content knowledge (PCK) for Physical Science, with the aim of improving the performance of their learners. The intervention consisted of workshops covering key topics in Grade 12 Physical Sciences, including: electrodynamics, electrochemistry, Newton's laws, vertical projectile motion, acids and bases, rates of reactions, chemical equilibrium, and organic chemistry. The selection of topics was informed by a pre-intervention questionnaire assessing teachers' needs. Collaboration was facilitated through a WhatsApp group for resource sharing and discussion, while individual support was informal and unstructured. The intervention spanned 16 hours, delivered through face-to-face sessions on Saturdays and online sessions on Wednesdays and Fridays after school hours. Digital access was not financially supported.

This paper presents the findings related to one group of participants: novice teachers – those with less than five years of teaching experience. Novice teachers were selected because they often experience transfer shock – a transition period caused by moving into an unfamiliar setting – making it difficult for them to adjust and to perform their jobs competently (Caspersen & Raaen, 2014). Rural South African schools often face a shortage of experienced teachers; in this context novice teachers may be required to teach subjects for which they have had no formal training to teach, exacerbating their experience of transfer shock (Du Plessis, Carroll, & Gillies, 2015). To make matters worse, as novice teachers are often appointed on a temporary basis in the South African school system, schools may not be willing to invest adequately in supporting them, leaving them to 'sink or swim' (Du Plessis, Gillies, & Carroll, 2014). Only three of the 13 teachers in the larger study were novices and thus participated in this study.

This study employed a qualitative approach as it focused on understanding how people perceive their experiences, the meanings they assign to those experiences, and how this shapes their reality (Merriam & Tisdell, 2016). A case study design was used, which provides "an in-depth description and analysis of a bounded system" (Merriam & Tisdell, 2016, p. 37). In this study, the three teachers constituted a multicase since the teachers had different qualifications, taught at different schools in the circuit, and had different lengths of teaching experience. An interpretivism paradigm was employed as it aims to understand human experiences from the perspective of those experiencing the phenomenon under study (Cohen, Manion, & Morrison, 2011).

Table 1, below, summarises the characteristics of the sample. The teachers' qualifications varied: one held a Bachelor of Education, while two held a Bachelor of Science: one had specialised in Mathematical Sciences and Statistics and the other – who was the only one with any training in the physical sciences – in Physics and Applied Mathematics. Thus, as the Grade 12 Physical Sciences subject is comprised of Physics and Chemistry, none of the three teachers had received adequate formal training in the subject. The three teachers each had two or three years of experience teaching Physical Science at the Grade 12 level; for two teachers, this represented their entire teaching experience, while the third had been teaching for 14 years previously.

Table 1.
Profile of participating novice teachers.

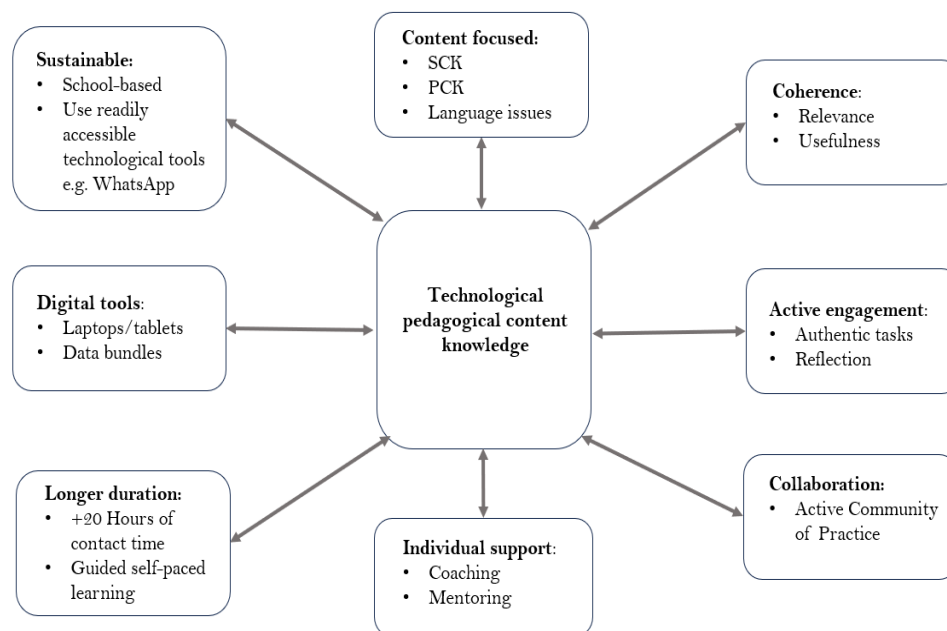
Teacher	Qualifications	Teaching Subjects	Teaching experience	Experience teaching Grade 12 Physical Science
Teacher 1	Bachelor of Education	Physical Sciences and Mathematics	2	2
Teacher 2	BSc in Mathematical Sciences and Statistics, PGCE; Pursuing BSc Hons in Statistics	Mathematics and Technology	3	3
Teacher 3	BSc in Physics and Applied Mathematics, PGCE	Mathematics and Natural Science	16	2

Data was collected from two lesson observations, which were video-recorded, and from semi-structured interviews with each novice teacher before and after the intervention. Field notes were also taken during the intervention workshops. Themes were generated inductively from the data in line with the aim of the study. To enhance the reliability and validity of the findings, triangulation of data sources, which entails the consultation of different sources of the data to support emerging findings, was used. This approach enabled cross-verification of information and identification of consistencies or discrepancies across different data sets, thereby providing a comprehensive understanding of the findings.

4. FINDINGS

Analysis of the data identified several key components, as shown in Figure 1, that are significant for enhancing the effectiveness of blended teacher professional development initiatives in rural areas to effectively support novice teachers: they should be sustainable, content focused, coherent, employ appropriate digital tools, promote active engagement, have adequate duration, provide individual support, and promote collaboration.

Figure 1.
Components that support effective blended teacher professional development in a rural context.



Each of these components is discussed below.

Content focused

The study found that the intervention's focus on promoting teachers' subject content knowledge (SCK) and their pedagogical content knowledge (PCK) – in tandem – was key to achieving the aim of the intervention. During the intervention, teachers participated in a total of eight workshops that were focused on Grade 12 Physical Science topics and how to teach them. While teachers' knowledge of these topics was enhanced, methods for teaching these topics were also shared with the teachers. The extracts below illustrate the teachers' views about the content focus of the workshops.

With the intervention, I got to learn a different approach introducing a topic or a different way of explaining the very same thing but with various options. It allows you to know that 'oh, it can also be tackled this way,' unlike if you just stick, or glued, to one way only. You may find that having different strategies for different learners helps. So, I think that one was very much helpful. (Teacher 3)

There's a part of electrochemistry. Actually, also with electrodynamics. There are certain things which I was not quite sure of and some things. Even if you can try to search from your textbook or Internet, you might find that explanation as saying that experience count. So, someone with experience has encountered these challenges not once, or two times. Later they found a solution. Then we got to be given the opportunity to receive the new strategies. That's why I'm saying in electrodynamics most of my learners got a total because we copied what we got from the intervention or from the workshop we attended there at School D. (Teacher 2)

There was a strategy that the facilitator was using on Paper One – on electrodynamics. I have copied that one the way it is. I came with it to my learners, and they understood within few minutes. I know that they know are good in that topic. I think maybe it's because of the way she taught the lesson. Then I also came and taught the same way, and learners were able to grasp it quick. (Teacher 1)

The excerpts above show that the teachers found the intervention beneficial as they learned new methods they could use to address each of the topics covered during the workshops. Teacher 2 indicated that he also had the opportunity to improve his content knowledge for some of the topics.

Coherence

This component emphasizes the importance of the relevance and usefulness of the professional development content. In the professional development intervention in this study, the teachers were asked to indicate which topics they found challenging and where they needed more training to be able to teach the Grade 12 Physical Science curriculum effectively.

'Acids and bases' was a topic that the teachers identified as challenging, followed by 'electricity', 'organic chemistry', and 'work, energy, and power'. While these particular topics were covered in the workshops, not all topics the teachers identified as challenging were addressed in the intervention. Other topics, such as 'organic chemistry', were selected by the workshop designers and facilitators based on their weighting in the examination and learners' past performance in recent years. Since the inclusion of the teachers' four priority topics in the workshop directly addressed their needs, they found the workshops relevant and useful to their teaching, as shown in the excerpts above.

Some of the workshops that focused on the topics that teachers had identified as challenging to teach were held a few days before the learners wrote the Physical Sciences preliminary examination. Some schools took advantage of the timing and had their learners participate in these workshops with their teachers. Teacher 2 explained that, during the workshop, the teachers would ask questions on behalf of their learners as the facilitators had not been informed that learners would be attending via the online link.

I was able to connect here [his classroom] and then they [learners] were listening. Yeah, they filled this place. They were watching here, and if we are busy asking questions, they were listening. I was asking questions as a learner, they were also listening and benefiting, taking notes. (Teacher 2)

In one of the workshops attended by Teacher 1's learners, the facilitator taught the learners directly, to demonstrate how the pedagogical content knowledge that the workshop was presenting could be implemented in the classroom and to enable the participating teachers to see how learners would respond. The teachers found this approach effective, as articulated by Teacher 3 in the excerpt below:

I think, soon, it would be best if, like, they did last intervention workshop at School A, where learners were amongst us. Yeah, I think that strategy can do miracles. Yeah, go to combine a whole lot of schools: it will require some financial muscles, yeah, but I think that could help. Yeah, because seeing different faces, presenting different chapters – it helps them. What happened after you left: we had a group of teachers rushing to School D to assist – teachers from different schools. Each teacher was

given a topic to address. We had this on Saturday and Sunday. So, it helps if they see different people. Yeah, you see, the approach will be different as well. (Teacher 3)

Teacher 3 reported that the strategies shared by the facilitators had been useful and that the teachers had immediately implemented them in their classrooms, on their own initiative.

Active engagement

This component stresses the need for critical reflection and authentic tasks. In this intervention, teachers were required to verbally reflect on their experiences with implementing the shared teaching and learning strategies at the beginning of each intervention workshop. During these reflective sessions, each teacher shared the challenges they had faced and these were discussed, with other participants sometimes suggesting solutions. The teachers were occasionally asked open-ended questions related to subject matter knowledge and pedagogical content knowledge during the workshops. Since active engagement in the workshops was limited to verbal reflections and question-and-response, it was found that the teachers would quickly lose interest, especially in the online workshops. For example, Teacher 1 indicated that they did not experience as much benefit from the online workshops as they did from face-to-face workshops.

Let me tell you why the online one doesn't work better. The online one: I'm alone – you do not see me – you only see any of the screen that you project there. In most case, I would be busy with my things, putting the phone down. There was a day when they asked me a question – I was not even there. I was called, saying they are looking for me. I was busy with my things. So, I lose concentration quicky with online workshops because I'm in my space – and if my in my space, I might even sleep. You will think I'm listening, and I am not, you see. So, I think the physical one is best because I'm here and you have my attention. (Teacher 1)

His experience may have been due to the online workshop not requiring participants to engage actively in authentic tasks: they were only asked to answer a question. This suggests that active engagement is critical in blended professional development initiatives, particularly in synchronous online workshops.

Collaboration

Collaboration emphasises the importance of establishing a community of practice and promoting active participation in it. Since the intervention was administered while the COVID-19 pandemic was at its peak and close interactions, such as group and peer discussions, were restricted, opportunities for teachers to seek assistance were limited. The distance between schools posed an additional barrier. To bridge this gap, a WhatsApp group was set up so that participants could contact the workshop facilitators and each other at any time.

The WhatsApp group was also used to share teaching and learning information and materials. For example, links to videos that the teachers could use were shared with them. Although the WhatsApp group could have been used extensively for collaboration, it was not effectively utilised to contribute meaningfully to the teachers' professional development through facilitated exchanges. This is because it was not utilised to promote collaboration amongst the teachers. Its use was limited to sending announcements to the teachers.

Individual support

Individual support could be provided through coaching or mentoring. The professional development intervention in this study did not use coaching and mentoring, but participants did have the opportunity to engage with their facilitators during short breaks or before and after each workshop – particularly during the face-to-face workshops, as shown in the excerpt below.

Personal interaction is also - because with this online thing, one might be busy with something else this side. They may be watching, but they won't participate fully. But if sometimes we do physical one, we get to see people, you share your concerns directly to the right person. (Teacher 3)

Professional development interventions should be designed to include opportunities for participants to engage with facilitators individually and receive tailored responses to their specific concerns.

Longer duration

The findings highlighted the importance of participants engaging for an extended period with the professional development material. The intervention involved 16 hours of engagement by the participants. However, this duration was not found to be adequate, as shown in the excerpt below.

Not really change per se, but I would say we would start as soon as possible. Unlike this year we started late but would start somewhere around February and we start working with them, gaining those new strategies and skills. (Teacher 2)

The excerpt above shows that the teacher found the contact time insufficient as he wanted to learn more and develop himself. In the excerpt above, Teacher 2 comments on the starting date of the intervention, which was during the third teaching block (August/September), a few weeks before the learners would write their preliminary examination for the subject. At this time of the year, teachers are expected to have completed teaching and assessment as per the curriculum for the grade. Thus, the teachers found that because the intervention was scheduled late in the year, it was too late for them to implement what they had learned in time for their learners to gain real benefits from it. Two teachers also requested that the facilitators assist them with the other Grade 12 Physical Sciences topics they found challenging to teach.

Digital tools

The study found that digital tools and internet access were needed for blended professional development to be delivered effectively. Participants need data bundles and laptops or tablets to participate in online sessions. In this study, participants were not provided with any resources to enable them to access the online workshops. Instead, they used their own resources. Teacher 1 reported that this compromised his ability to participate in the online sessions:

For those workshops that are online, data is expensive. If you request the school to help you with data, they say no or promise to assist but they never do. There was this one time where I attended half of the session, because I received a text stating that I have used 50% of the data. (Teacher 1)

Teacher 3 also raised the need for participants to be provided data so that they can participate in online workshops:

Sometimes – like the online one – you must have enough data to listen and participate – all of that. So, you might find that a teacher might be logged in now for 10-15 minutes, then he's out – just like that. I don't know how, but if there were some sponsors somehow that could help supplement a little in terms of data, which could be another issue. (Teacher 3)

This is indicated in Table 2 below, which shows the amount of time the three teachers spent attending the online workshops.

Table 2.
Attendance duration of the teachers per online workshop.

	Newton's laws Workshop	Vertical projectile	Acids and bases	Rates of Reactions
Teacher 1	39m 23s			1h 32m
Teacher 2	42m 23s			1h 36m
Teacher 3			1h 40m	1h 40m

Table 2 above shows that all three teachers had the longest attendance duration at the workshop that covered the topic 'rates of reactions'; they attended for almost two hours. Their longer attendance duration at this workshop may be attributed to the fact that the learners were going to be examined on that topic the following Monday, in their national preliminary examinations.

Furthermore, the organisers assumed that all the participants could access the internet from their school and had access to a smart phone or laptop from which they could log into the online workshops. The excerpt below from Teacher 2 shows the influence of poor network on his attendance of online workshops.

So, the only challenge with online, you know online we'll be experiencing maybe network problem. You know. I remember there was one which I couldn't even log in because of network. I remember I was not around; I [attended the online] workshop and at the place [where I joined the online workshop at], my network was not supported, I am using Telkom. So, if I'll be having a challenge of network, it means I won't be able to attend. (Teacher 2)

While it is said that one can attend online workshops anywhere, this excerpt demonstrates that poor connection resulting from poor network coverage can obstruct attendance, thereby hindering engagement.

Sustainability

The study found sustainability to be an important component in the success of the intervention, in terms of using readily available technological resources. To support this, teachers were provided with three key resources during the initial workshop: micro kits for

Chemistry and Physics experiments, an examination guideline for Grade 12 learners, and a booklet covering previous exam questions from various provinces. These resources aimed to aid teaching and learning. The micro kits allowed teachers to demonstrate scientific concepts, while the examination guideline and booklet helped familiarize students with exam structures and probed learners' understanding of the topics. These materials are reusable and adaptable for various topics in Physical Sciences, thus supporting long-term benefits. Additionally, the intervention demonstrated practical teaching strategies using the limited resources available at Teacher 1 schools, showing teachers how to apply these methods in their own contexts. This approach helped teachers to continue developing their skills even without the facilitator, promoting sustainability.

Technological pedagogical content knowledge (TPCK)

The study found that the TPCK competence of facilitators was key to the success of the intervention, as poor technical pedagogical competence could result in passive learning. For example, Teacher explained that he often got distracted during online workshops, sometimes attending to unrelated tasks, or even falling asleep, as shown in the excerpt below.

The was a day when they asked me a question, I was not even there. I was called saying they are looking for me. I was busy with my things. So, I lose concentration quicky with online workshops because I'm in my space and if am in my space I might even sleep. (Teacher 1)

Teacher 1 expressed the view that not being physically present at the workshop made it harder for him to stay focused and engaged. He found online workshops ineffective due to a lack of active engagement, a problem that seemed to be exacerbated by the absence of collaborative tasks. Observations of intervention workshops showed a lack of activities that promoted active engagement or collaboration; instead, teachers sat passively as content was delivered. Boredom and disengagement may have also result if the participants did not find the content relevant; for example, the teachers generally did not find the topic 'electromagnetics' challenging to teach, but it was covered during the workshop. The facilitator's TPCK competence plays a significant role in the effectiveness of blended professional development. As shown in Figure 1, TPCK serves as an anchor for the other components of blended professional development, with teachers' experiences of blended professional development strongly influenced by the choices made by the facilitators. In addition, participants also need adequate technological competence to use the digital tools required to participate in online learning.

5. DISCUSSION

The findings of this study show strong similarity to those facilitated in various modes, e.g. online and/or face to face, although not in South Africa, as reported in literature (see Darling-Hammond et al., 2017; Desimone, 2009; Patton et al., 2015; Powell & Bodur, 2019). This study affirms previous claims that content focus that builds teachers' SCK and PCK, coherence, collaboration, active engagement, and longer duration are important to the success of teacher professional development initiatives, regardless of the mode of facilitation. In this study, the intervention improved the teachers' SCK and PCK, particularly for the two teachers who were teaching Physical Science yet were unqualified to teach it (Teachers 2 and 3). The teachers also found the professional development initiative to be aligned to their needs, as it addressed some of the topics they had identified as challenging. This aligns with Letloenyane

and Jita's (2020) claim that teachers participate in professional development to benefit their learners.

While active engagement was found to be an important component, in this study, it was challenging to achieve in the online sessions of the intervention as the facilitators lacked adequate TPCK competence to use the available technology effectively to actively engage participants. As Powell and Bodur (2019) point out, simply changing the mode of professional development without adapting the activities and facilitation approach does not guarantee that teachers will benefit substantially from the intervention. In this study, WhatsApp was used a platform to transmit information, although it could have been used as a vehicle to promote sustainable teacher professional development. The novice teachers reported sleepiness and difficulty paying attention during online workshops. These findings support Gherheş et al.'s (2021) argument that, when participants turn their cameras off, there is no evidence that they are actively engaged in the workshops. This demonstrates that effective TPCK competence is necessary to craft online professional development experiences that employ all components effectively to ensure that the intervention yields positive outcomes. This also highlights the important role of facilitators, whom Perry and Booth (2024) say are under-researched, with their importance in making professional development beneficial to the teachers and learners undermined.

However, the components outlined above are not sufficient for teachers in rural areas, particularly novices who often finds themselves teaching subjects that they are not qualified to teach, such as Teachers 2 and 3. The findings of this study show that these teachers also require individual support. This would enable the teachers to share their concerns with the facilitators in safe spaces without fearing negative consequences. These findings are similar to those of Hunt-Barron et al. (2015), who report that teachers preferred to email the facilitators for assistance instead of posting on shared platforms.

Although blended professional development can offer greater flexibility and accessibility, it also demands digital resources. This includes data and a device with the necessary capabilities to enable the user to participate in synchronous workshops and complete activities, as recommended by Mukuna and Aloka (2020). Since these resources were not provided to the participants in this study, their attendance was affected, as shown in Table 2. In addition to the need for data and devices, this study found that poor network coverage may also affect teachers' attendance and engagement in workshops. This requires alternatives to online synchronous workshops that take into account the significant workloads that rural teachers often carry, leaving them with limited personal time to engage in reflective online tasks or asynchronous interactions, as found by Hunt-Barron et al. (2015).

6. CONCLUSION

The results of this study suggest that for blended professional development to be effective in rural areas, it must incorporate the strengths of both online and traditional professional development modes while addressing the unique challenges of the rural context. While the frameworks and models proposed by Philipsen et al. (2019) and Wittmann and Olivier (2021) provide a valuable foundation for modelling the key components of effective blended professional development interventions, they do not consider the limiting factors experienced by teachers at rural schools in South Africa, which include limited access to network and digital tools, time constraints, and the need for individual support which enables access to privacy. To enhance the effectiveness of blended professional development initiatives in rural contexts, they should be aligned with the technological, geographical, and resource-related challenges faced by teachers in rural areas. They should provide teachers

with the digital tools and competence necessary to fully engage in online professional development activities, as recommended by Mukuna and Aloba (2020). Due to the heavy workloads and time limitations experienced by teachers at rural schools, professional development initiatives should allow for asynchronous participation and flexible deadlines while ensuring that teachers receive individual support. Lastly, facilitators must have the necessary technological competences to be able to effectively integrate technology into their pedagogies and content knowledge during teacher professional development interventions. While this study involved a small sample, the findings have significant implications that organisers of professional development initiatives should consider to enhance the success of blended professional development in shaping teaching practices. It is recommended that further studies be conducted to further understand these blended teacher professional development components not only in rural contexts but also in other contexts.

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Chapter # 30

STUDENTS' USE OF LEARNING VIDEOS

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ABSTRACT

As digital learning grows, understanding student engagement with educational videos is essential, yet few quantitative studies exist within Norwegian educational research. This study addresses that gap by surveying over 1,400 Western Norway University of Applied Sciences (HVL) students with 252 responses to explore their video preferences, viewing habits, and perceived benefits. Results show that, while students rate external videos from elite institutions higher in technical quality, they still prefer videos made by their lecturers over hybrid teaching videos. Academic relevance stood out as the most important factor, with content quality prioritized well above other considerations like pedagogical approach, video length, and technical features. Students use videos as a general learning aid throughout the semester, not just for exam preparation, and prefer videos to be available before class, supporting flipped classroom methods. These findings suggest that educators focus on creating accessible, content-centered videos aligned with course needs to enhance student engagement and learning outcomes.

Keywords: instructional videos, video production, flipped classroom, blended learning.

1. INTRODUCTION

In recent years, the use of video as an educational tool has gained considerable popularity among students at various levels of education. This trend is primarily driven by the increasing availability of digital devices and the proliferation of online learning platforms. Video offers a dynamic and engaging way to present information, making it easier to understand and remember complex concepts. Naturally, audiovisual means (streaming, video, self-created, or accessible from the Internet) are helpful for teaching, especially with universities having multiple campuses with similar courses.

The COVID-19 pandemic has significantly affected how students learn and prepare for exams. Before the pandemic, traditional teaching methods such as classroom lectures and face-to-face consultations with teachers were prevalent. However, remote teaching became necessary during the pandemic, accelerating technology adaptation in education, including using video as one of the most important teaching tools.

An example is the Western Norway University of Applied Sciences (HVL), which has five campuses between 100 and 400 kilometers apart. Over the past eight years, studies have taken away experiences in distance learning (Fojcik et al., 2020). This research showed significant differences in video use depending on the field of study. Thus, nursing students watched videos before lectures, as predicted by the flipped classroom model (Baig & Yadegaridehkordi, 2023), at a significantly higher rate than engineering students. In contrast, engineering students often use video during their final exam preparation (Sande, Leite, & Kyte, 2021).

As time passes, the demand for flexible education is growing, with students wanting to study remotely either at their place of residence or alongside work. As a result, many universities now offer this form of education (Pollen, Fojcik, & Kampen, 2022).

How should a video be created? How does it fit into different forms and courses of study? Should the teacher deliver videos, or should students create reports and exams in video form instead of submitting written work? Proper preparation and use of these elements can help develop important soft skills such as creativity, communication, and source criticism (Poláková et al., 2023).

A meta-study (Guo, Kim, & Rubin, 2014) found that students prefer short videos, and that relevant content is more important than technical quality. Clark (1993) compares the medium to a truck delivering education: the quality of the truck is not more important than the quality of the load. Using an attractive medium does not automatically improve the learning process.

This article examines what HVL students think about watching videos in their learning process, including advantages and disadvantages. The study aims to understand how students use video content for learning, identify key parameters that make educational videos effective, and understand students' expectations of such resources. By analyzing these aspects, we can gain insights into students' preferences and behaviors, which can contribute to developing more effective educational video materials. Understanding these factors is crucial for educators, content creators, and academic institutions that want to use video as a powerful tool to improve students' learning experiences. The survey was conducted in the spring and fall of 2024.

2. RELATED WORKS

Due to the demands of modern, tech-savvy students and the availability of technology, higher education institutions need to transform traditional teaching methods (Moussiades, Kazanidis, & Iliopoulou, 2019). Developing software tailored to teaching (such as various types of LMS or audio-video programs, Zoom, Teams, Google meetings, ...), infrastructure, and data transmission systems (Ndjuluwa, Adebisi, & Abdulsalam, 2024) have facilitated new technologies. Video is also gaining popularity in the educational landscape. It is recognized that video can bring theoretical concepts to life with vivid images and spark students' imagination (Abdous & Yoshimura, 2010; Chan, 2010; Pelton, 2013). Therefore, teachers in schools and universities are increasingly encouraged to use video instruction in teaching and to develop students' learning skills through video. Empirical research on the use of video indicates that video is a powerful medium for presenting learning materials, demonstrating experts, delivering and repeating lectures, and exploring complex scenarios (Berk, 2009; Moussiades et al., 2019). As a result, most universities have begun to combine live teaching with various digital approaches, representing a blended or hybrid teaching perspective (Islam, Sarker & Islam, 2021). Video-based learning (VBL) is integral to blended learning, especially in flipped classrooms and MOOCs (Massive Open Online Courses).

According to de Boer (2013, p. 17), the development of digital networks such as the Internet has made it possible to watch video at any time, regardless of schedule. It has also led to a particular teaching detachment from a specific location (i.e., the classroom). Video can be viewed on any computer connected to the Internet. Siemens, Gasevic and Dawson (2015, p. 205) refer to this as “the idea of classroom constraints, where teachers can now use different technologies and collaborate with students and content around the world.” This, in turn, has led to opportunities outside the classroom with the advent of MOOCs (Fox, 2013;

Baggaley, 2014) and is leading to a transformation of the educational landscape (Bates, 2015).

It is not easy to imagine modern teaching without video elements (Andrist, Chepp, Dean, & Miller, 2014), which allow students to engage with the material before class at their convenience. On the other hand, using digital elements such as video content is not limited to students engaging in independent study, i.e., watching a particular video at their own time and pace. Digital elements are also used for formal teaching. The fact that video can also be integrated into face-to-face sessions means that the use of video is not limited to an add-on component (Andrist et al., 2014).

Various videos have been produced in the education sector, each with its own aspects and functions. Categorizing, describing, and defining the differences between the different forms is a complex process, and due to the dynamic nature of the field, it is constantly evolving. Changes are necessary for lecturers moving from face-to-face teaching to video instruction with screen processing. How to do this effectively while keeping the focus on the teaching process without getting lost in the complexity of new technologies is an ongoing challenge. For some lecturers, it may seem controversial to record their classes on social media and make them available to a broader audience. However, it is highly likely that video instruction will become more standard over time (Woolfitt, 2015).

Shephard (2003, p. 295) noted more than two decades ago that "video has been used in a variety of ways over the years to support student learning in all branches of education." Access to websites such as YouTube, Facebook, TeacherTube, and others has improved significantly in recent years, and most of them are freely available to students and faculty. There are also several specific videos created for our educational purposes, made by academics and with the same intent as ours, to explore the use of self-produced videos for students. There are examples of video use that are evaluated in learning and teaching in higher education, as Shephard (2003) noted.

Mitra, Lewin-Jones, Barrett, and Williamson (2010) studied students' perceptions about the use of video in lectures and seminars to assess whether video can enhance student learning and encourage critical engagement with topics. The results are based on the opinions of 134 students and 20 semi-structured interviews. Some results point to the importance of lecturers clearly describing the purpose of watching videos and using it to elicit reflection and/or discussion, making it less likely that students will remain passive. The lecturer needs to state the tasks clearly before watching the video. How lecturers use videos will determine whether it is an effective learning tool. Video can be essential in higher education when used critically and as part of a blended learning approach.

Most existing research in this area has often focused on the lecturer's perspective and experience of appropriate technology use (Cook-Sather, 2003; Lee & Sharma, 2008). Guo et al. (2014) found that videos should be short, around 6 minutes, and that content, rather than technical quality, was most important to students.

Gedera and Zalipour (2018) stressed the importance of constructing interactive videos that build on interactive learning moments where deep learning occurs. Interactive video allows students to participate actively in the learning process. To create interactive video learning moments, it is essential to provide an explanatory understanding of the content, ask questions about it, and encourage students to discuss and reflect. Iskru and Schulz (2020) wrote an article about the importance of defining what is seen as video learning. Video learning stems from students' cognitive engagement in meaningful learning experiences in which they interact with the material and learn to construct their knowledge. The student's ability to apply new information to solve a problem in a different, related context is seen as an academic achievement. The teacher's role is first to create conditions in which the student's

old knowledge is supplemented with new knowledge and, secondly, to help the student discover their full potential. Mayer (2008) and Wischgoll, Pauli, and Reusser (2019) write that what is essential for effective learning is the activation of the student's cognitive processes and that this cognitive activation takes place in an environment where it is not dangerous to make mistakes but an opportunity to learn with and from each other (Stanford, 1977).

Masats and Dooly (2011) focus on using video cases in teacher education, which can be divided into three categories depending on how the video was used: video viewing, video modeling, and video coaching. Özkan (2002) had a similar idea about using video cases in teacher education. Video viewing often focuses students' and teachers' attention on specific subjects, providing a basis for classroom assignments and discussions. Video modeling is a means to concentrate student-teacher attention on target skills or behaviors. Video coaching refers to using collected activities that lead to group discussion.

Research shows that teachers who incorporate technology to create videos for use in teaching provide essential information for the overall development of future teachers (Cullen, 1991). Research also indicates that students trained in technology/video construction will use this knowledge in their teaching situations (McKinney, 1998; Goldsby & Fazal, 2012). Achieving constructed knowledge, developing reflective skills, and creating critical video producers are essential.

3. METHODOLOGY

This section outlines the research design, participant demographics, survey methods, and analytical strategies used to examine educational video use at HVL.

3.1. Study Design

We employed a mixed-methods approach using a cross-sectional survey to gather quantitative data from structured questions and qualitative data from open-ended responses. This approach enabled us to comprehensively explore student attitudes and behaviors related to educational video use. The survey targeted specific dimensions of video engagement, including preferences for video length, the importance of technical features such as subtitles, and the timing of video consumption.

The study focused on three key aspects of video usage: the timing of video consumption (whether students watch videos before class, after lectures, or throughout the semester), engagement with video content (preferences for video length, subtitles, and quality), and content type (preferences for lecturer-made versus external videos). These variables aligned the study with the core objective of understanding how video features and usage patterns support student learning at HVL.

3.2. Participants

The survey targeted 1,404 HVL students. Participants ranged in age from 18 to over 40, with a gender distribution of 60% male and 40% female. The sample included students from various academic levels across programs such as Electronics, IT/Computer Engineering, Technology, and Nursing. Students from the Førde, Haugesund, and Bergen campuses, including on-campus and distance learners, were represented.

3.3. Survey Questionnaire

The questionnaire, administered via the SurveyXact platform, consisted of 30 questions designed to gather data on student video usage - the questions aimed at collecting information on the frequency of video use, content preferences, and quality. Multiple-choice questions assessed preferences for different video sources, such as instructor-made videos and those from external platforms. Yes/no questions addressed basic usage patterns and general opinions on videos as a teaching tool. In contrast, open-ended questions provided insights into preferences related to video features, such as the importance of subtitles.

Modifications from previous surveys included adding new questions and refinements based on earlier feedback. These adjustments allowed for a more detailed exploration of how students engage with video content in their learning process.

3.4. Data Collection

Data was collected during the Fall 2024 semester using SurveyXact. The survey link was distributed through Canvas, the university's learning management system (LMS). To boost participation, reminders were sent through the LMS. A convenience sampling approach was used to gather responses from a diverse range of students across different programs and academic levels. The survey achieved a response rate of 18%.

3.5. Data Analysis

Data analysis primarily relied on exploration and visual methods to identify response patterns. Descriptive statistics, including percentages, means, and standard deviations, were used to summarize the data. At the same time, visualizations such as histograms and box plots highlighted key trends to provide an intuitive understanding of video usage preferences. When relevant, missing data were labeled as "uncertain" responses. The analysis was conducted using Excel.

3.6. Ethical Considerations

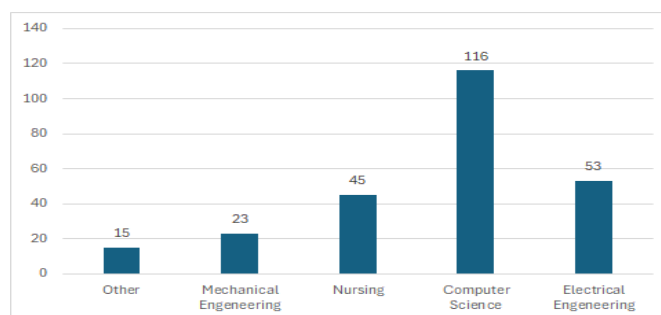
The study was reported to the Norwegian Agency for Shared Services in Education and Research (SIKT), reference number 639645. As the questionnaire also included open-ended questions, SIKT required that the project have routines for removing any personal data appearing in free text fields continuously and within one month at the latest. This was done. Thus, the project did not process data that could identify individuals directly or indirectly. SIKT, therefore, stated that the project did not need an assessment from Data Protection Services and discontinued further follow-up of the project.

Higher age ranges were grouped to ensure anonymity during the analysis process, and programs with few respondents were merged. Data is securely stored with restricted access to the research team for potential future analysis in compliance with ethical standards.

4. RESULTS

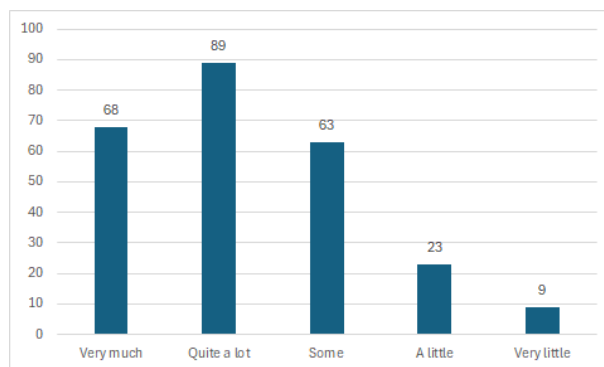
The y-axis shows the number of students in all the figures below except Figure 8, which shows points. Most of the students who answered the survey were bachelor students: 113 in their third year, 76 in their second year, and 60 in their first year. 164 out of 252 students (65%) work while studying. 97% of the students watch videos as part of their learning process. 76.7% of the students attend classes; the rest opt out of meeting in person.

*Figure 1.
Students and field of study.*

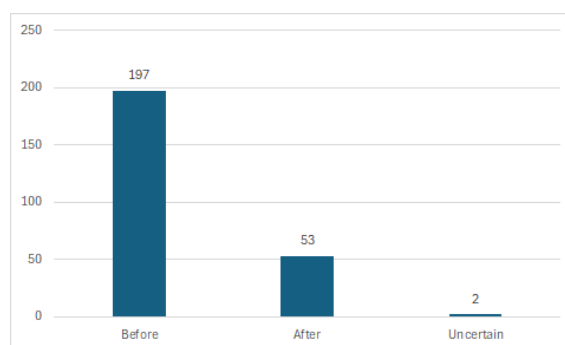


All the respondents watch videos, but to a varying degree. When asked how many hours they watch videos weekly, 22% of the respondents watch between 1 and 3 hours, 34% between 3-6 hours, and 23% between 6-12 hours. Most respondents (65.5%) prefer videos made by their professor, and 12.3% want a recording of entire lectures. The rest of the respondents are uncertain or prefer videos from other universities/other sources.

*Figure 2.
To what extent are the videos used?*

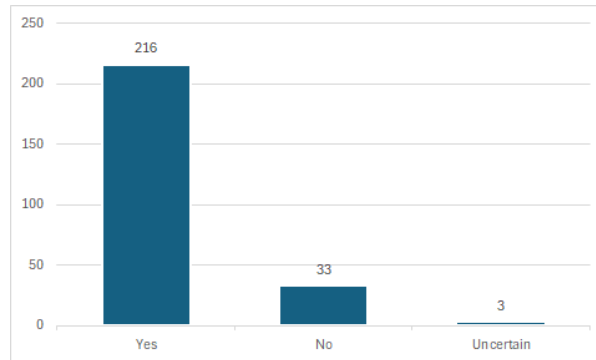


*Figure 3.
Should videos be added to the LMS before or after class?*



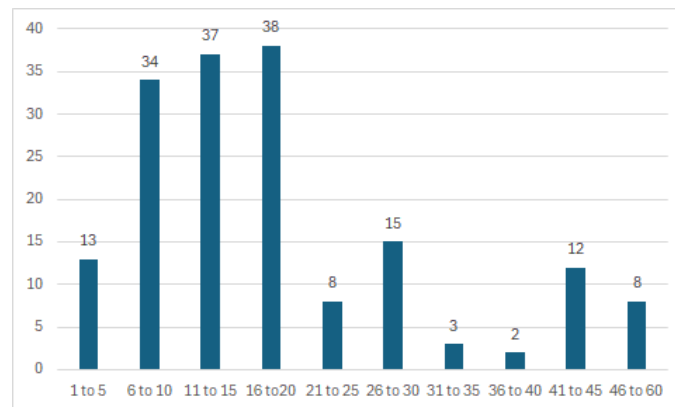
Approximately 80% of the respondents want videos available before classes. When asked whether they watch videos before or after lectures, 21 respondents answered before, 60 after, and 169 both before and after.

Figure 4.
Do you use videos throughout the semester?



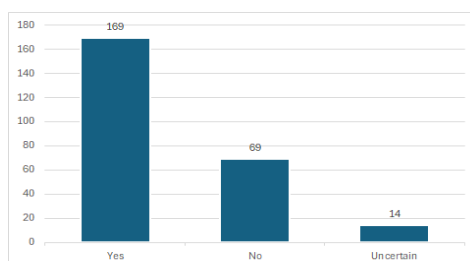
86% of the respondents watch videos throughout the semester. When questioned whether they watched the entire video, 187 respondents answered yes, and 61 answered no.

Figure 5.
Opinions on how long a video should be in minutes.



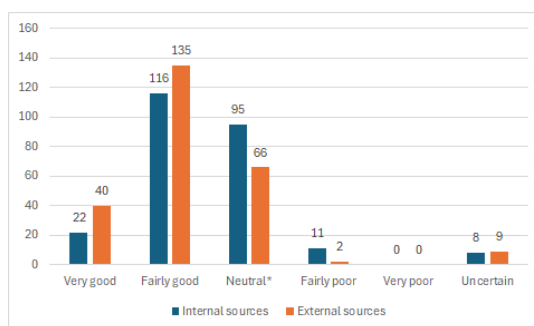
Approximately 52% of the respondents believe the video should be between 6 and 20 minutes long. 19% are uncertain.

Figure 6.
Should the videos be subtitled?



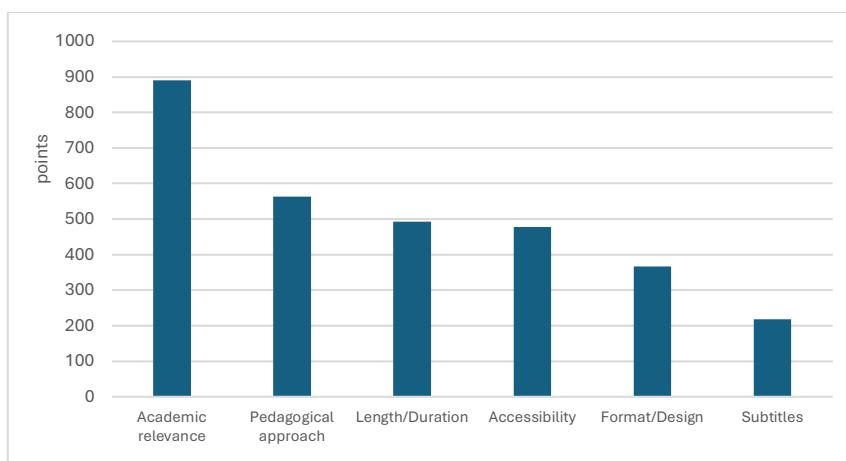
67% of the respondents want subtitled videos. 127 respondents want Norwegian subtitles, 21 want English, and 96 want both languages.

Figure 7.
Opinions on video quality.



We see that the respondents think the quality of the videos from internal and external sources is satisfactory. However, videos from external sources have slightly better scores.

Figure 8.
What is most important when watching a video?



Students gave their priorities (1-6) for different aspects of the video. We used the Borda count [Wikipedia, 2024] system and processed the questions, assigning 5 points for first place, 4 for second place, and so on. The results show that academic relevance is by far the most important. Next is a pedagogical approach, followed immediately by *length* and *accessibility*.

On the question, "Would you like to submit video assignments?" 170 (67.5%) of the respondents answered no, 62 (24.6%) respondents yes, and 20 respondents did not know.

5. DISCUSSION

The meta-survey (Guo et al., 2014) showed that students wanted short video clips and that relevant content was more important than technical quality (Clark, 1993). This finding is supported by the fact that the content is most important, not the packaging. The survey by Guo and others was conducted 10 years ago and much has changed since then.

Students today expect that there are videos available that can be used to support their learning process. It is an important part of the flipped classroom (Baig & Yadegaridehkordi, 2023). Our survey shows that the students use several different learning resources, from textbooks and online resources to materials made by their teacher. Most students watch videos in their learning process, but at different times. The idea behind the flipped classroom is that the students should prepare before they come to class (Baig & Yadegaridehkordi, 2023), but this happens to varying degrees.

The students believe that the content is essential, but set demands for sound and subtitling. If you use a good microphone so that the sound is good, the first recording is usually good enough and does not need to be edited. This means that you do not need to spend much time creating technically perfect videos, but rather spend time creating good educational content. A student states, "the video could well be a recording of a calculation with pen and paper" (freely translated from Norwegian).

Mitra et al. (2010) conducted a similar study on students' perceptions of video use. The teacher should clearly describe the purpose of watching the video and how it should be used. This may engage the students and prevent them from becoming passive. The teacher must specify tasks before watching the video. Our survey shows the importance of making video resources available in the LMS before teaching sessions, even though not all the students watch them immediately.

Iskru and Schulz (2020) discuss the importance of specifying what is perceived as learning through video. Video learning results from students' cognitive engagement in meaningful learning experiences where they interact with the material and learn to construct their knowledge. The student's ability to apply new information to solve a problem in another related context is perceived as an academic achievement. Mayer (2008) and Wischgoll et al. (2019) state that what is essential for promoting effective learning is that the teaching activates the student's cognitive processes and that this cognitive activation takes place in an environment where it is not dangerous to make mistakes, but instead used as an opportunity to learn with and from each other (Stanford, 1977). Although our survey wants to learn more about the students' use of video resources, our underlying aim will be to use their cognitive abilities and processes, such as perception, thinking, learning, problem-solving, and attention.

The students think the videos should be subtitled, as some speak indistinctly, and it is not always easy to understand different dialects. Subtitles in both Norwegian and English are desired. English subtitling is very good using YouTube, but Norwegian text recognition has

been poor up until now. Norwegian is a small language, but better AI tools are now on the market, so adding Norwegian subtitles today requires minimal extra work.

The students can watch videos longer than the recommended length of 6 minutes (Guo, et al., 2014). Videos can be indexed so that you can fast-forward to what you seek. They prefer videos made by subject teachers, but also videos they find online. In higher education, you must acquire not only subject competence but also so-called soft skills, such as creativity, the ability to communicate, the ability to collaborate, the ability to exercise source criticism, and persistence (Poláková et al., 2023). Learning requires determination and is time-consuming, as it is individual how long it takes to acquire new skills. This means that the length of the video is not decisive, but it must be easy to find what you want to see.

A survey at our university before the pandemic showed a difference between the student groups (Sande et al., 2021) in engineering and nursing education. The nursing students watched videos beforehand, as is the intention of the flipped classroom, while the engineering students watched the videos after the lecture. Our survey shows that the students now, after the pandemic, when they got used to video and video recording of lectures, watch videos to a much greater extent before the lectures.

Approximately 25% of students want to make a video for work requirements. The use of videos is an integral part of lifelong learning (Sullivan, Fulcher-Rood, et al. 2019), and colleagues in a workplace must also teach each other. Competence in making good videos becomes essential; they should learn that during their education. Therefore, we should introduce video submission as a work requirement in some subjects. It also means that the students should be instructed on making good videos and which tools they can use.

6. CONCLUSION

Our survey shows that students use video resources actively in their learning process. Videos made by teachers are good enough; they do not have to be perfect. They want the videos to be available to them before class, which can make the flipped classroom work as intended. The students point out that the content of the video is the most important, and then the way the teacher presents the material. We have been focusing on making short videos, which is less important than we thought. Our students do not want to make videos as submissions, and they prefer to use written work instead. We must work on it, teach them how to make videos, and thus try to inspire them that way. The student responses are a great inspiration for us to continue facilitating learning by creating digital learning resources.

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Chapter # 31

INNOVATIVE EDUCATION AND LIFE CYCLE ASSESSMENT OF 3D PRINTED PRODUCTS

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ABSTRACT

The chapter is devoted to life cycle assessment, specifically determining the carbon footprint of a product produced with the help of a 3D printer. At the beginning of the chapter, mind maps are described that relate to a specific product printed on a 3D printer, which has clearly defined goals: to describe the individual phases of the product's life cycle; orientate yourself in concepts related to product quality; define product life cycle costs; assess the impact of various factors on product quality; to evaluate the impact of production using a 3D printer on the environment. There are various calculators for calculating emissions, which, after filling in, will evaluate the result. However, it is often impossible to look at how the process was calculated to know how a particular value arrived at. Calculations were calculated in Microsoft Excel, where clear methods of calculation were presented to the students. At the end of the chapter, there are recommendations for applying the sustainable development of active learning methods to teaching.

Keywords: life cycle assessment, production process diagram, 3D printing, product quality, active learning methods.

1. INTRODUCTION

Sustainable development and environmental management make it possible to satisfy the needs of the human population and, at the same time, do not threaten the standard of living of future generations while preserving the intact ecosystem of our planet. Environmental management is a comprehensive approach to managing and minimizing the impact of human activities on the environment. It includes the various processes, tools and strategies that organizations use to achieve sustainability and environmental protection. Here are some key aspects of environmental management:

- i. **Environmental Management Systems (EMS):** These systems, such as ISO 14001 and ISO 50001, help industrial companies systematically improve their environmental performance and improve energy efficiency. EMS includes the planning, implementation, control and continuous improvement of environmental policies and procedures.
- ii. **Identification and evaluation of environmental aspects:** Industrial companies must identify and evaluate their environmental aspects, which are elements of their activities, products or services that may have an impact on the environment. This includes, for example, energy consumption, waste production and emissions.
- iii. **Planning and implementation of measures:** Based on the identified aspects, industrial companies plan and implement measures to minimize negative

- impacts on the environment. This can include energy savings, recycling, emissions reduction and other green initiatives.
- iv. **Monitoring and measurement:** Industrial companies must regularly monitor and measure their environmental performance to ensure that their measures are effective and that they are achieving their objectives.
- v. **Employee training and involvement:** A key part of environmental management is employee training and involvement in environmental initiatives. This includes raising awareness of environmental issues and promoting sustainable behaviour in the workplace.
- vi. **Certification and audits:** Industrial companies can obtain certification of their environmental management systems through independent audits that verify that they meet the requirements of standards such as ISO 14001.
- vii. **Life Cycle Assessment (LCA):** One part of the environmental management is LCA. LCA is a system analysis focused on collecting and evaluating inputs, outputs, and possible impacts of a product (or service) on the environment during the entire life cycle. During the assessment, all impacts associated with the product are mapped, from the extraction of raw materials, production, and use to the end of the product's useful life and disposal.

Thus, environmental management is made up of a wide range of rules, activities and processes, including a number of documents, all of which help organizations and manufacturing companies manage their impacts on the environment and thus contribute to sustainable development and the future. If environmental management can be introduced to schools, it will play an irreplaceable role in education for sustainable development and environmental education in schools. The key question is how to approach the teaching of sustainable development in schools and how to familiarize pupils with the topic. In addition to basic information about the reasons for the emergence of the idea of sustainable development, its application in specific practical areas is also extremely important. The concept of education has a great advantage for sustainable development and aims to ensure the effectiveness of educational activities and maximum adaptation to the needs of both individual students and society as a whole, using current educational content and connecting it with extracurricular activities or everyday life (Mwendwa, 2017; Hernández-Díaz, Polanco, Escobar-Sierra, & Leal Filho, 2021); Fekih Zguir, Dubis & Koç, 2022). Another important aspect of education for sustainable development is maximum student involvement. 3D printing is generally recognized as an effective and sustainable technology, and in recent years, considerable research and development has taken place, including technological innovations in industrial enterprises to support 3D printing for better production processes and its activities (Zhichao, Qiuhong, Zhang, Tao & Zhang, 2016; Krotký, Honzíková, & Moc, 2016; Böhm et al., 2023). 3D printing technology can be applied, for example, in civil construction, mechanical engineering, electrical engineering, medicine, education, art, and confectionery. 3D printing has a significant impact on the environment; for example, this technology can reduce the amount of waste, as additive manufacturing produces less waste than traditional methods, which often involve cutting material. Among the advantages of 3D printing is the increasing use of recycled materials, which leads to a reduction in the consumption of new raw materials. The possibility of local production is another advantage, which leads to a reduction in logistics and transport costs and, thus, a reduction in the associated carbon footprint. The use of 3D printing in education at secondary vocational schools can have its advantages and disadvantages. Gaining practical skills in the areas of design, modelling, calculation, and production is one of the advantages that can increase the competitiveness of secondary school students in the labour market or allow them to more

easily participate in university projects as part of their studies at universities. The knowledge gained in 3D printing can be used in various subjects, from mathematics and physics to art, which can also support students' creativity and innovative thinking, which is another advantage of 3D technology (Bull et al., 2010; Ford & Minshall, 2019; Assante, Cennamo, & Placidi, 2020). However, there are also challenges that need to be overcome, such as the lack of the high financial costs of purchasing, operating and maintaining 3D printers. Research on 3D printing in Korea shows that teachers in both undergraduate and pre-service education lack the digital literacy and confidence needed to teach 3D printing technology, identifies the scope of knowledge required for teacher qualification, and defines steps for integrating 3D printing technology into individual classrooms (Song, 2018). The lack of methodology for the effective implementation of 3D printing in education at secondary vocational schools can be another obstacle that needs to be overcome. An online questionnaire study was conducted with teachers in Germany who had varying experiences with 3D printing technology, where almost half of teachers have 3D printers in their schools, while their use is even less widespread (Thyssen & Meier, 2023). The use of 3D printing is being applied worldwide, for example, in an Australian secondary school, an ethnographic study was conducted, where an analysis of the curricular activity was carried out from three different perspectives: the facilities involved in the project, the social and educational contexts, and the activities during the project implementation. Based on the evaluation of the results, it was highlighted how complex and complicated it is to implement the technologies in school contexts, especially the ways in technical and/or pedagogical innovations associated with 3D printing are possible (Nemorin, & Selwyn, 2016).

This contribution demonstrates the impact of 3D printing on the environment, leading to an understanding of the issues surrounding 3D printing while providing researchers and educators with better guidance for future research.

2. EDUCATION FOR SUSTAINABLE DEVELOPMENT

Education for Sustainable Development (ESD) is an important and key tool for building a more sustainable future, not only in educational institutions such as universities and secondary schools. The educational process must focus on developing the values and attitudes needed to address global challenges such as climate change, starting from primary schools. The goals of ESD, which are closely linked to the 17 Sustainable Development Goals (SDGs), are to empower individuals to make informed decisions and take responsible actions for environmental integrity, economic viability and a just society, both for current and future generations (United Nations, 2024, Transforming our world: the 2030 Agenda for Sustainable Development). Integrating sustainability into education involves including topics such as climate change, sustainable agriculture, renewable energy sources, and nature conservation in the school curriculum (Thürer, Tomašević, Stevenson, Qu, & Huisingsh, 2018; Fekih Zguir et al., 2022). This approach also connects different subjects and disciplines so that students understand the complexity and interconnectedness of global problems. It is important to mention holistic learning here, which supports the cognitive, socio-emotional and behavioral dimensions of education, and this includes, for example, the development of critical thinking, analytical skills and the ability to analyze and solve problems (Hernández-Díaz et al., 2021). Education for sustainable development also connects different subjects within a discipline but also connects individual programs, and promotes cooperation and respect for different cultures and opinions, which can also lead to lasting sustainable development (Mwendwa, 2017). Lifelong learning is not limited to formal (e.g. schools, universities, educational institutions) education but extends to non-formal (e.g. projects, workshops, public campaigns) and informal education. Informal education then refers to

learning from everyday experiences, media and social networks. ESD is crucial for the future of our planet and society (Tasdemir & Gazo, 2020). This concept of education for sustainable development includes four main areas such as economic, environmental, social and cultural (see Table 1), and each of these areas brings unique insights and methods to education.

Table 1.
Education for Sustainable Development (ESD).

Nr.:	Perspective	Goals	Methods
1.	Economic	Understanding basic economic principles; Promoting sustainable business and innovation; Supporting fair trade and economic justice;	Entrepreneurship projects: Students can create their own business plans focused on sustainability, such as eco-friendly products or services. Case study analysis: Students can study successful examples of sustainable businesses and discuss their strategies. Economic scenario simulations: Through simulations, students can understand the impacts of various economic decisions on the environment and society.
2.	Environmental	Raising awareness about nature conservation; Promoting sustainable use of natural resources; Reducing the ecological footprint of individuals and communities;	Field research: Students can conduct research in nature, such as monitoring biodiversity or water quality. Ecological projects: Schools can organize projects focused on recycling, composting, or creating school gardens. Recycling and upcycling: Students can create artworks or useful items from recycled materials.
3	Social	Promoting social justice and equality; Strengthening community development and cooperation. Raising awareness about human rights and social issues.	Discussions and debates: Students can discuss current social issues and seek solutions. Volunteer activities: Engaging students in volunteer activities in local communities, such as helping in charitable organizations. Collaboration with local communities: Projects that connect schools with local communities, such as workshops.
4	Cultural	Promoting respect for different cultures and traditions; Preserving and celebrating cultural heritage; Supporting intercultural understanding and dialogue.	Cultural exchanges: Organizing exchange programs or virtual meetings with students from other countries. Study of world cultures: Including the study of various cultures in the curriculum. Art projects: Creating artworks inspired by different cultures and traditions.

A comprehensive approach to education for sustainable development helps secondary vocational school students develop the skills and knowledge necessary to address global environmental challenges and also helps students better understand complex problems and seek new solutions.

The first phase is the concept and development, beginning with the initial idea and its implementation from prototype to serial form. It involves the compilation of various ideas and information and their gradual incorporation into a new product, followed by testing, market launch and marketing. The next phase is the growth phase, which involves the launch of product sales when the product gains popularity and increases market share. This phase can be described as the beginning of revenue compared to the development phase. After growth comes the maturity phase, where the growth of the market itself stops. This period is the period of the highest return on the product, when sales peak and stabilize, including cost optimization. This is followed by the decline phase, when interest in the product decreases, for example, due to new technologies or changes in customer requirements. The decision to withdraw a product from the market is a complex task. The last phase is disposal when the product is safely disposed of or recycled. Each of these phases has specific approaches and contains a series of calculations and analyses that can be used to plan for the success of the product and to maximize its lifespan, including financial profit.

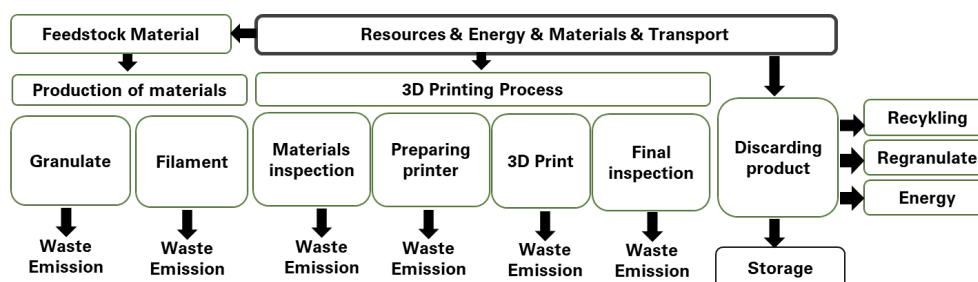
Costs are also related to product life cycle and sustainable development, and it is very important to familiarize students with this. Life cycle costs are total (cumulative) and can be divided into acquisition costs (for example, market research, project design and management, software development), ownership costs (for example, production planning, quality management, maintenance of production equipment, modernization, employee training), costs for disposal (for example collection and processing of non-functional products, legal fees (Ans & Koç, 2023; Bertini, Buehler, Halbheer & Lehmann. 2022)).

2.1. Life Cycle Assessment of a Product From a 3D Printer

3D printing begins by creating a model of an object on a computer. One way is to create the model manually using a CAD (Computer Assisted Design) application or other 3D modelling software, and an alternative is to create a digital model by scanning the actual object with a 3D scanner. In general, there are three categories of 3D printing: selective binding, selective solidification, and selective deposition. The most commonly used technologies are usually called SLS (selective laser sintering), SLA (stereolithography), DLP (digital light processing), FDM (fused deposition modelling), or FFF (fused filament fabrication). Given the current trend of linking teaching with practice, the use of printers for educational purposes appears to be a very suitable tool for teaching, especially technical subjects. 3D printing technologies are a field that is very promising in itself today, as they find their application in various sectors, within which many companies use it as the main production equipment and allow the creation of complex geometries that would be difficult or impossible to produce using traditional methods, thereby reducing waste (Zhichao et al., 2016).

But even for 3D printing, an environmental analysis is necessary. It is interesting to study that home 3D printing produces minimal waste, reducing its environmental impact. Home 3D printing reduces transportation needs, including packaging, which means less plastic (Drizo & Pegna, 2016). That's why we used a home 3D printer (Prusa MK2.5 3D printer located in the university laboratory) to calculate the Life cycle assessment of a product.

Figure 1.
Scheme of the production process of 3D printing



2.2. Creation of a Carbon Footprint Calculator

Choosing the right emission factors is the key to correctly calculating the carbon footprint, but unfortunately, it is not always easy to calculate. Emission factors represent the amount of greenhouse gas emissions per unit of activity or quantity, and their correct selection depends on data sources, specificity, and geographic location. Determining the boundaries of analysis is a key initial step for any carbon footprint analysis. There are three main approaches: organizational boundaries, operational boundaries, and system boundaries. These limits determine what emissions will be included in the calculation. Practical steps include identifying emission sources, collecting data and applying emission factors. It is also important to check and validate the calculations, ideally through an external audit. The following stages were chosen to determine the product's greenhouse gas emissions using 3D printing: material transportation, production of Polyethylene terephthalate (PET) material granules, energy consumed for printing, and material recycling PET. It means determining which steps of the production process (Figure 1) are included in the calculation of greenhouse gas emissions and which are not.

2.2.1. Material Transportation

Emissions arise during the transportation of raw materials to the production plant. This includes fuel consumption and CO₂ emissions from vehicles.

Calculation of CO₂ emissions for 1 litre of diesel fuel: 1,92 kg of oxygen is needed to burn 1 litre of diesel fuel (0,84 kg); the resulting carbon dioxide is equal to the sum of 0,72 kg of carbon and 1,92 kg of oxygen, which is 2,64 kg of CO₂ from 1 litre of diesel fuel burned (Baťhová, 2021). The amount of carbon dioxide that a vehicle emits into the air is directly proportional to the amount of fuel it consumes and the carbon content of the given type of fuel. PET material is produced from oil and natural gas, which we import, for example, from Saudi Arabia (Hamieh et al., 2022). The road distance between the Czech Republic and Saudi Arabia was considered to be 5295 km. The total fuel consumption of diesel fuel is 371 litres.

2.2.2. Production of Polyethylene Terephthalate (PET) Material Granules

The production of PET granules begins with the raw materials, which are ethylene glycol and terephthalic acid or dimethyl terephthalate. These raw materials are derived from petroleum and natural gas. The production process starts with polymerization. This process occurs in two main steps: esterification and polycondensation. The resulting PET polymer is then melted and passed through an extruder, where it is formed into long fibres. These fibres are then cooled and cut into small granules. Finally, the PET granules are dried and conditioned to remove moisture and improve their processability for subsequent 3D printing.

Consumption of basic raw materials to produce 1 kg of PET granulate: oil 0,64 kg (33,18 MJ) and natural gas 0,23 kg (12,63 MJ) and CO₂ in the production of 1 kg of PET granulate is 2,3 kg (Příbylová, 2000).

2.2.3. Energy Consumed for Printing

The university's laboratory carried out calculating CO₂ emissions related to the printing process and energy consumption per 1 kg of product. Prusa MK2.5 3D printer was used to print the product. Consumption for preheating the pad and nozzle was 11 Wh (40 kJ). Energy 93 Wh (335 kJ) was used to print a product weighing 4,14 g. The energy to print 1 kg is 22,5 kWh (81 MJ). From the statistical data of the Ministry of Industry and Trade of the Czech Republic, the value of the CO₂ emission factor from public electricity production for the year 2022 was 0,413 t CO₂/MWh. When 1 MWh of electricity is produced in the Czech Republic, 413 kg of CO₂ is released (430 g of CO₂ is released when 1 kWh of electricity is produced).

2.2.4. Material Recycling PET

When calculating CO₂ for PET recycling, it was assumed that the combustion would take place in a high-quality incinerator, where a highly controlled combustion process would burn PET and produce carbon dioxide and water. The amount of CO₂ is calculated from the PET chemical formula: HO- [-CH₂ -CH₂ -O-OC- C₆H₄ -CO- O-] n -OH. Burning 1 kg of PET produces 2,2 kg of CO₂. In the case of incomplete combustion, other substances can be formed, which can also cause an increase in CO₂ values.

3. CONCLUSION

Elementary, secondary, and grammar schools and universities can effectively incorporate the concept of education for sustainable development (ESD) into their curricula, which will allow them to combine traditional teaching topics and newly integrate economic, social, environmental, and cultural elements. It is equally important to methodologically connect secondary school teaching with the real world. To achieve this, the method of locally embedded and situational learning, which is characteristic of ESD, is proposed. ESD implemented through projects where engaged learning and experiential pedagogy can be applied. Holistic integration of sustainable development across all subjects in secondary vocational schools, including community involvement and manufacturing industries, can improve learning outcomes. It can be stated that effective education for sustainable development also requires very well-trained teachers; therefore, individual personal professional development plans should be created that will allow teachers to grow professionally based on completing various training courses, workshops or participating in conferences. Student grading and assessment and its development is another aspect that needs to change in the context of sustainable development in secondary vocational schools, which means that traditional examinations may not be relevant, so alternative assessment methods should be considered, such as assessment based on personal projects.

Materials innovation is key to advancing 3D printing research, and this includes investigating product design and the properties of selected materials, which will require product and material analysis and subsequent assessment of factors and risks, such as storage conditions, manufacturing conditions, quality control, and data evaluation. It is also important to conduct a more thorough analysis of 3D printing-related CO₂ emissions, including specific case studies, which will provide insight into their overall environmental impact, including energy consumption during production and end-of-life disposal options. Innovations in the field of 3D printing should subsequently be reflected in teaching at universities and high schools.

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Chapter # 32

AN AFROCENTRIC APPROACH TO ANALYSING LITERARY TEXT THROUGH AFRICAN VALUES IN ENGLISH FIRST ADDITIONAL LANGUAGE

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ABSTRACT

Literature and culture have an interlinked relationship, and prescribed literature texts have a fundamental role in ensuring that these coexist harmoniously. Centralising African Values in prescribed literature should be prioritised in South African classrooms, to achieve the nationally aspired decolonised approach to education. This paper explores the teaching of these African Values in prescribed literature, particularly short stories. This qualitative study uses textual analysis to generate data with the Afrocentric paradigm as the conceptual underpinning for the study. Reviere's (2001) Afrocentric canons show how African values can be taught. The paper presents the context, methodology and doctrinal underpinning of Afrocentrism before using Afrocentrism as a tool to analyse a text. We also look at the functions of texts for young adults to distinguish ideological purpose and as a vehicle for transmitting cultural values. The paper recommends that teachers and learners be conscious of these Afrocentric values and their impact on literary analysis in South African classrooms.

Keywords: Afrocentrism, African values, literary analysis, Afrocentric paradigm.

1. INTRODUCTION

1.1. Context Background and Doctrinal Underpinning

For centuries, African literature, through stories and folktales, educated generations about culture and societal systems. Colonization silenced the African voice, replacing it with Eurocentric perspectives in formal education. This shift alienated African learners and denied them a culturally relevant educational experience. In South Africa, calls for decolonization have grown, particularly in education, with political unrest since 2014/15 highlighting the absence of Afrocentric approaches in Higher and Basic Education. English curricula often perpetuate Eurocentric ideologies (Zulu, 2006), neglecting authentic African values essential for cultural enrichment. Afrocentric pedagogy offers a means to restore cultural authenticity and decolonize education. Mugambiwa (2021) argues that Afrocentricity helps reclaim African lived experiences, while Omolewa (2007) emphasizes its role in preserving the past and ensuring a sustainable future.

This study demonstrates Afrocentric analysis of prescribed literary texts in South African classrooms, focusing on five Afrocentric values—Ukweli, Kujitoea, Utulivu, Ujamaa, and Uhaki. Through a detailed analysis of a short story, the study illustrates how these values uncover African cultural perspectives and enhance pedagogical relevance. The findings provide recommendations for integrating Afrocentric methodologies into teaching, offering valuable insights for educators and policymakers committed to promoting cultural authenticity and decolonizing education.

1.2. Scientific Approach

Studies by Asante (1991) and Mazama (2001) define Afrocentrism, a concept that underpins this research. Scholars acknowledge Asante (1991) as the father of Afrocentrism, which he defined as a belief system wherein African experiences are interpreted from the perspective of African people (p.171). Mazama (2001) describes this research approach and paradigm as a disciplinary environment arising out of a particular philosophical belief system characterized by a specific theoretical framing, methodology and principles inspired and denoted from the truths and perspectives of African people (p. 394). This understanding of Afrocentrism is used in this study to form its paradigm, methodology, and critical concept for exploring prescribed literature.

This understanding of Afrocentrism revealed the need to question prescribed literature about its compliance with Afrocentric principles and education. A study by Giddings (2001) found that the missing Afrocentric approach in the American curriculum created many problems for African American learners, who experienced frustration because the curriculum content did not accommodate them. Amongst some of the goals for an infused Afrocentric curriculum, Giddings (2001) found that an Afrocentric curriculum provided students of African origin with educational instructions to build a positive self-image because it employed practices aligned with their learning styles and helped build a positive self-image. Asante (1990) found that when teachers used an Afrocentric approach, African students did not question their own dignity when their people's stories were not understood from their African perspectives. These students saw themselves portrayed as subjects having agency instead of being the object of education, especially in literary texts where African students come to see themselves as integral participants and not as foreign seekers of knowledge.

1.3. African Values

According to Asante (1991), Reviere (2001) and Van Wyk (2014), five values are identifiable in Afrocentrism, namely, *Ukweli*, *utulivu*, *uhaki*, *ujamaa* and *kujitoa*. These will be used as a tool for inquiry in this research. The values derived from Swahili relate to an African method of enquiry. These values, called canons, appear in many African fields of inquiry and disciplines, such as psychology, agriculture, social work, and Indigenous Knowledge education. These canons require considering the traditional beliefs and intentions of the partisan, philosophical, and community and stakeholders. They focus on methods for disseminating knowledge and how such knowledge is structured and applied to enable understanding and cultural relevance. Florian and Hawkins (2011) posit that the canons seek out layers of cultural subtext beyond what the literature reveals.

1.3.1. *Ukweli*

uKweli translates to “the truth or fact, that which is authentic to the people”. This is evidence that literary processes and practices are rooted in the knowledge of the community they serve. Van Wyk (2014) believes that engagement with the community is the sole determinant of what is learned from literature and how literature is mediated (p. 293). This means that the real-life experiences of the community members, which are real and true to them, become the standard for determining the literary needs of the community. *UKweli* raises the issue of the partisan nature of what truth is (Van Wyk, 2014). Afrocentrism does not advocate that the ‘truth’, as experienced by one member, has more validity than that experienced by another.

1.3.2. *Kujitoa*

Kujitoa, which is the harnessing of devotion and commitment, requires that literature prioritize how knowledge is organized and generated instead of emphasizing the need for dispassion (Van Wyk, 2014). She posits that this will reveal the hidden assumption in literature (p.293) and address how knowledge is structured and used.

1.3.3. *Utulivu*

Utulivu derives from the spirit of serenity, tranquillity, and harmony, values that have always been treasured and are functional in African societies (Reviere, 2001). In literary analysis, *Utulivu* requires that literature consciously avoid generating, amplifying or sustaining community disunity. Literature should aim to create and foster harmony and peaceful relations among community members. This value is embedded in a fundamental principle summarising the African view of humanity, namely Ubuntu, which is the acceptance that “I am because we are; and since we are, therefore I am” (Mbiti, 1979, p. 141). Kunene (1982) affirms that social cohesion is fundamental to African society and believes the earliest manifestation of civilization was establishing a supportive community collaborating with each other. *Utulivu* scrutinizes literature for its role in providing peaceful resolutions and advocating positive resolution of problems encountered. Historical and contemporary Eurocentric trends in literature have often cited literary creativity as the reason for leaving resolutions unattended with little consideration for communal problem-solving methods.

1.3.4. *Ujamaa*

Ujamaa translates to the disposition of brotherhood and collective advancement (Reviere, 2001). It gained popularity in Tanzania as a socio-economic policy after independence from Britain. In literature, it deals with the rejection of separating the generation of knowledge from its communal owners and literature creators. As Van Wyk (2014) believes, it presumes that literature is the well from which knowledge springs.

1.3.5. *Uhaki*

Uhaki entails that literature be fair, mindful and empathetic to the community it serves. *Uhaki* entails the process of literary justice, which suggests that literature should not discount the past and collective experience in its interpretation and response to the community it serves (Reviere, 2001). It also requires that the literature is not contributory to the detriment of any of its stakeholders (Van Wyk, 2014).

2. AFROCENTRISM AND THE TEACHING OF LITERATURE IN ENGLISH FIRST ADDITIONAL LANGUAGE

2.1. Cultural Values

Teaching literature can contribute positively to understanding the culture where the literature originates. Bredella and Haack (1988) believe that when one wants to understand a culture, one must adopt the ontological assumptions of the community and use their epistemology to understand what they believe and consider important. The encounter with an unknown culture can be a liberating experience, providing a new perspective for understanding oneself and one's community (Bredella & Haack, 1988, p. 4).

As Syndram (1991) asserts, literature is an aesthetically expressive medium with persuasive power to transmit cultural values and ideals. Bredella and Haack (1988) assert

that the study of literature entails investigating the basic values and beliefs of culture from different perspectives, and studying the narratology exposes the reader to other worlds and cultures, which will be experienced from alternative viewpoints.

2.2. Why we teach Literature

This chapter seeks to demonstrate the use of prescribed youth texts taught at the secondary school level to sensitize learners to Afrocentric values embedded in texts. Therefore, it is prudent to understand the functions of youth literary texts and why the study of literature is included in the curriculum.

Ghesquiere (1993) identifies three primary functions of the literary texts. There is a psychological function where the reader gains insight into his emotions and experiences. While appreciating the aesthetics of the literary work, the reader will also acquire language skills and develop his cognitive abilities. Of interest to this paper is the social function arising from engagement with the literary text. When we introduce the reader to the community that produces the text, we teach them socialization skills. Socialization occurs when the reader learns about the community's values, norms and prejudices portrayed in the text. The reading of literature transmits culture when the reader becomes aware of his rights, obligations and freedom in the context in which he exists. Therefore, an Afrocentric analysis of texts will transmit the African values mentioned above.

2.3. Afrocentrism and the Decolonizing of Literary Texts

Afrocentrism, an interdisciplinary approach, should be integrated into teaching, including literature (Oliver, 1998). Eurocentric paradigms have often misinterpreted Africana cultural realities, viewing them as deficient in culture, politics, and economics (Pellerin, 2012). Asante's (2009) concept of Afrocentrism offers an alternative framework for analyzing literature, positioning Africana people at the center of their historical and socio-political narratives. This perspective has gained traction in regions like America, the Caribbean, and Africa as a tool for addressing historical injustices and redefining African identity (Mkhabela, 2005). Colonized nations, including South Africa, have inadequately addressed the impacts of Western influence on education, particularly in literature. As advocated by Diop (1974) and Asante (2007), Afrocentric methodologies promote African agency by rewriting diaspora histories and rejecting Eurocentric hierarchies. Reviere (2001) asserts that Afrocentricity fosters liberating and rewarding interpretations for African people. This approach emphasizes "epistemological centeredness," where Africans become agents rather than objects of inquiry (Mazama, 2001, p.542). Afrocentrism organizes African experiences through shared cultural perceptions and rejects dogmatic distinctions, encouraging the integration of material and spiritual realities (Semmes, 1981).

As both a paradigm and methodology, Afrocentrism uncovers African values and scholarship in literature, offering a transformative lens for analyzing texts and promoting an authentic cultural identity.

3. EXAMPLE OF ANALYZING A TEXT FROM AN AFROCENTRIC PERSPECTIVE

The study employs Van's (2009) 4 elements of textual analysis to decipher the short story, which include plot, setting, character and themes. The plot was understood as a planned, logical series of events with a beginning, middle, and end. Usually, a short story has one plot, so it can be read in one sitting. The plot was studied in order to understand how the

author arranges events to develop the basic idea. The setting was understood as the Time and Location of the short story. When the study examined how the setting contributed to the short stories, it considered the geographical location, historical period, weather conditions, social conditions and the author's attempt at accurately recording the emotive atmosphere of the time. The characters were understood to be the beings that lived and thought in the short story to keep the action going. The study looked at who these characters were, their relationship and connection to each other, their worldviews, their ideas about themselves and others, and how they grew, changed and developed to influence the story. The study also focused on the story's central message and moral to understand the themes. This was done to understand the author's views on human nature.

To conduct an Afrocentric analysis of the short story, Van (2009) 4 elements of textual analysis integrated with Reviere's (2001) Afrocentric canons. The table below illustrates the intersectionality of both lenses in analyzing a short story:

Table 1.
Summary of the Afrocentric analysis lens applied in the short story.

	<i>uKweli</i>	<i>Kujitoea & Utulivu</i>	<i>uJamaa</i>	<i>uHaki</i>
Plot	Did the events in the plot offer the characters enough space to experience a truthful reality?	Was the rising conflict resolved in a manner that promoted harmony in the represented community?	Do the events in the story consider the aspired interest of the community?	Do the events in the story actively represent a search for justice? Does that particular justice serve the interest of the community?
Setting	What are the dimensions of the setting? Is this true for the community that is being represented in the story?	Was there any harmony during the time in which the story was set? How is this displayed?	Does the setting accurately portray the identity of the community in the short story?	Does the setting take into consideration the injustices and oppression of the community?
Characterisation	How true are the characters representation regarding the community they are in? How is this truth validated in the characters representation?	Did the characters actions towards themselves and the people around them create harmony in the community they are represented in?	What are the characters affiliation to the community they are represented in?	Does the character's growth and development highlight the search for communal justice?
Theme	Was the theme truthful to the setting? Was the theme explored an accurate depiction of what the community holds as truth?	What are the hidden inaccurate assumptions that present the community in a false inharmonious manner?	Does the theme represent the current social issues facing the community?	Do the themes in the short story prioritize the search for justice and fairness in the African community?

3.1.1. Summary of the Short Story

Sophia Zikode, the protagonist, faces misfortune with dark magic after migrating to Johannesburg for work. She falls for a married man, Elias, who leaves her, and later for Jonas, a foreigner. Insecure, she seeks help from a traditional doctor, receiving a potion that turns into a fortune snake. Advised to pass it to an unsuspecting person, Sophia eventually transfers it to Elias's mother at a train station. She then leaves for Malawi with Jonas, while Elias inherits the curse.

3.1.2. African Values and their Representation in the Short Story

All the Afrocentric canons were studied in this short story in each of the 4 elements to find the African Values present in the story and how they were represented. The following themes are a few examples that were noted:

a) *Ukweli*

Characterization

Sophia's characterization embodies Ukweli, or truth, as a naïve rural girl navigating urban life. Her lack of romantic experience reflects the cultural norms of her rural upbringing, where structured practices guide relationships. This truthful depiction highlights the emotional servitude common among women in such settings, authentically portraying Sophia's reality.

Before coming to work in the golden city, Sophia had never had a steady boyfriend. But one man remained her lover for longer than the others. His name was Elias Malina from Ermelo. He was the first man she met in Johannesburg and the only man she truly loved. So besotted was she with this man that she readily discarded any possessions or habits that Elias disliked.

Setting

Set in apartheid-era Johannesburg, the story reflects the reality of many Black South African women, like Sophia, who left rural homes to work as domestic workers for white families. During this period, 18% of women were in domestic work, with 80% being poorly educated Black South Africans (Dinkelman & Ranchod, 2012). Sophia's isolation represents this common experience, as her family is notably absent.

She worked in a Johannesburg suburb and lived in the servant's quarters attached to the white family's house. Before coming to work in the golden city, Sophia had never had a steady boyfriend.

Plot

The first conflict arises when Elias ends his relationship with Sophia, leaving her desperate and heartbroken. Isolated as a rural immigrant, Sophia's naivety and inexperience with love keep her fixated on Elias, whom she believes is her only chance at love. Meanwhile, Elias, familiar with urban life, easily moves on, knowing he has family support and other opportunities. This dynamic reflects Ukweli by truthfully depicting their contrasting backgrounds and reactions to the breakup. Studies have noted that rural-to-urban migration often exacerbates vulnerability in relationships, particularly for women, due to unfamiliar social norms and limited support systems (Posel & Casale, 2003).

One day, Sophia and Elias had a quarrel. Elias got up and walked out on her. A few days went by. A week. Sophia could bear it no longer. She phoned his place of employment and

asked to speak to him. A friend came to the phone and told the distraught woman that Elias had had enough of her. She never heard from him again.

Theme

A key theme reflecting Ukweli in the short story is the belief in the supernatural and its impact, as seen in Sophia and Jonas's unquestioning acceptance of the fortune snake's power. This reflects a truthful depiction of African communities, where spirituality, benefiting the collective, is distinct from dark magic, often associated with individualistic harm. Such cultural frameworks highlight the communal understanding of supernatural forces in African societies (Mbiti, 1979).

b) Kujitoo & Utulivu

Characterization

Sheila, a supportive neighbour, embodies the African values of Kujitoo and Utulivu by fostering harmony and Ubuntu. When Sophia and Jonas encounter the fortune snake, Sheila offers refuge and comfort, continuously supporting Sophia in resolving the issue. Her actions underscore how African communities rely on collective support during crises, reflecting the spirit of Ubuntu as described by Mangena (2016).

They ran to a neighbour's house and knocked on the door of the servant's compound. Sophia's friend Sheila opened up. Quickly, they told Sheila what had happened. She gave them both some clothes for the sake of warmth and decency. Sheila's own boyfriend had left a coat in her room, and she gave it to Jonas. Then, the threesome went back to Sophia's room.

Sophia and Jonas decided to visit a traditional doctor for advice. They chose a man who lived a few streets away. Sheila accompanied them...

Setting

Sophia's encounter with the police highlights a lack of Kujitoo and Utulivu, reflecting the disharmony of apartheid suburbia. African people were restricted from being in suburban areas at night without permits, limiting their freedom and enforcing segregation. This systemic control, aimed at minimizing contact with white communities, underscored the oppressive disharmony of the setting (Dubow, 1995).

A few police cars patrolled the affluent suburb. Probably because of the high rate of 'housebreaking,' she thought to herself. There were two policemen in the van. 'What are you doing here?' he demanded. 'I'm waiting for a taxi,' said Sophia. 'I'm going to the station'. She was surprised that her voice sounded so steady. 'We don't want to find you here when we come back,' warned the policeman, eyeing the suitcase. The van pulled away slowly.

Plot

Sophia's interaction with the taxi driver highlights a lack of harmony, as he persistently questions her suitcase's contents, follows her, and publicly humiliates her. This contrasts with the African cultural value of supporting women in distress. Understanding such dynamics requires recognizing cultural practices that privilege empathy and support for vulnerable women (Maposa, Muriuki, Moss, & Kpebo, 2016).

'Hey, you girl! Where do you think you are going?' it was the voice of the taxi driver. She stopped dead in her tracks but did not turn around. She felt a lump in her throat, and tears

began to roll down her cheeks. She shook with anger. Suddenly she turned around and screamed at the man. 'What do you want from me!' 'You are running away from something, and you are trying to cover your tracks,' said the taxi driver smugly.

Theme

The values of Kujitoe and Utulivu are reflected in the theme of harmony for some characters. Sophia's journey, marked by struggles with love, loss, and the fortune snake, concludes with her finding peace. She comes to terms with her past, let's go of Elias, and starts a harmonious new life in Malawi, free from the curse of the Mamlambo snake.

The plane took off, and the crowds waved cheerfully. Sophia felt it was taking her away from the monster that had terrified her a few weeks ago...

c) uJamaa

Characterization

Sophia's character reflects uJamaa, emphasizing community participation and Ubuntu, though it also highlights cultural contradictions. Traditionally, African women are not obligated to submit to unmarried men, as marriage formalizes male leadership in households. Sophia's submission to Elias, a married man, deviates from cultural norms, illustrating the dissonance between rural values and urban relationships. Such cultural clashes often lead to unfavourable outcomes (Varga, 1997)

So besotted was she with this man that she readily discarded any possessions or habits that Elias disliked

Setting

The lack of uJamaa is evident in the short story's focus on the fortune snake, a practice taboo in African culture. Dark magic, often associated with selfish motives, contrasts with communal African values. The rise of practices like fortune snakes emerged during colonization, as segregation and poverty led some to seek quick wealth through harmful means. Witchcraft, distinct from sorcery, often exploited cultural vulnerabilities in urban settings (Middleton & Winter, 1963; Harwood, 1970)

Mamlambo is a kind of snake that brings fortune to anyone who accommodates it. One's money multiplies incredibly. This snake is available from traditional doctors who provide instructions regarding its exploitation. Certain necessities are to be sacrificed in order to maintain it. Sometimes, you may have to sacrifice your own children or go without a car or clothes. It all depends on the instructions of the doctor concerned

Plot

The plot highlights uJamaa through the concept of a community tribunal, where conflicts are judged collectively by elders. Such systems aim to resolve disputes harmoniously, reflecting African values of communal justice. However, in the story, the taxi driver wrongly involves the community, and the tribunal fails, necessitating police intervention. This underscores the erosion of traditional conflict resolution practices, as Kariuki (2015) noted, who emphasizes elders' enduring role in African societies for conflict prevention and resolution.

'Off you go then, before I arrest you for public disturbance'. He waved the man off. Then he turned to Sophia. 'My child,' the policeman said kindly, 'go where you are going. This rascal has no business to interfere in your affairs'. Relieved, Sophia picked up her suitcase and thanked the policeman.

Theme

A key theme in the short story is how characters' actions influence each other and the community. The value of uJamaa is evident as characters face challenges and strive to correct mistakes impacting the community. Their consequences highlight the importance of practicing Ubuntu and adhering to communal aspirations, as deviations result in significant repercussions.

d) uHaki

Characterization

The value of uhaki, or justice, highlights the lack of communal justice in the story, as seen in the characters' European names. During apartheid, African workers were stripped of their names and identities to suit white employers. Many named their children European names to secure future employment, erasing cultural connections. This historical injustice profoundly impacted African identity, reflecting the psychological toll of colonial oppression (Ngugi wa Thiong'o, 1986).

Sophia, Elias, Jonas, Sheila

Setting

Most of the African characters in the short story are represented as rural immigrants who came to Johannesburg to find work. This shows the value of uHaki because it shows past injustices. The Apartheid system made it impossible for African men to feed their families while still living in rural areas. When the government confiscated their livestock and commodities, it forced African men to relocate to the city and provide cheap labour to mines and homes of white people.

*Before coming to work in the golden city, Sophia had never...
His name was Elias Malina from Ermelo..*

Plot

Sophia shows a lack of uHaki in her conduct. The traditional doctor advised her to give the snake to any unsuspecting person she would meet. Old people are placed on a high pedestal in the African community. The community works to preserve, nurture, protect and care for the elders. Therefore, Sophia should not have given the snake to the old lady because this is taking advantage of her elderly, caring nature.

The conversation was very easy with this friendly old lady. As they spoke, more and more people spilled on the platform. Then Sophia made her decision. 'Gogo, will you look after my suitcase while I go to the shop?' 'I won't be long'

Theme

The short story takes us through how fortune favours the brave. Nonetheless, uHaki is shown in the theme of the Short in the conclusion of every character. Throughout the story, the characters do different things for themselves and the community. Uhaki is seen in how destiny and karma play out for each character. Justice is served for all the work that each character does.

4. CONCLUSION

This study employed Reviere's (2001) Afrocentric canons—Ukweli, uHaki, uJamaa, Kujitoo, and utulivu—to explore African values within the literature. While these principles have been applied in various disciplines, their use in literary analysis remains rare. The findings reveal that African values are deeply embedded in the story analysed, highlighting their significance in literature and daily life. However, fully harnessing these values requires deliberate pedagogical strategies and resources.

The study recommends prioritizing Afrocentric approaches in literature education, including curriculum reforms and developing teaching methods emphasizing African values. Future research should focus on integrating these values into classroom practices and revising educational policies to support an Afrocentric agenda. Addressing this gap is essential for fostering a more inclusive and culturally reflective approach to literature studies.

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An Afrocentric Approach to Analysing Literary Text Through African Values in English First
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Section 3

Teaching and Learning

Chapter # 33

DEVELOPING EMOTIONAL LITERACY, SUPPORT OF EMOTION REGULATION AND PSYCHOLOGICAL RESILIENCE IN THE CONTEXT OF LEARNING PROGRAMS

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ABSTRACT

The chapter presents the main findings of a research project aimed at methodology for developing and strengthening resilience and emotional literacy for teachers. The aim of this thesis is to find out what are the needs of today's teachers in the area of emotional literacy and the appropriateness of applying the proposed training programme. In the theoretical section, the concepts of emotion, emotion regulation, social skills and communication, resilience and their relevance to the profession of teachers are explained. The training programme is developed for continuous training of teachers in the form of presentations. The outputs of the project include an empirically validated, theory-based methodology manual for teachers to strengthen their psychological resilience. Teachers' practice and experience indicate a strong need for further training in the area of emotions and emotion management. After completing the training programme, the teachers' expectations were met and they expressed their satisfaction with the implementation of the emotional skills training and the promotion of their self-development. The programme was designed to stimulate teachers' interest in further exploring ways of learning. In the future the preparation of webinars for the acquisition of the methodology in the form of a short-term training programme for teachers using e-learning.

Keywords: emotional literacy, regulation, resilience, learning program, training of teachers.

1. INTRODUCTION

As part of the crosscutting literacy agenda for education (SVP, 2023/831:7-A2140), we have focused on developing and strengthening social and emotional literacy in schools. Social and emotional literacy is an important part of strengthening a person's psychological resilience (Ungar, Theron, & Höltge, 2023). In a rapidly changing world, reflection on learning, action and expression, communication, should be an essential part of the educational process. Moreover, the mental health of teachers has been deteriorating in recent years (Madarasová Gecková, Husárová et al., 2023; Cefai, Simões, & Caravita, 2021). The main goals of education include, among others, that also teachers develop appropriate key competences, knowledge and gradually cultivate a foundation of interest in lifelong learning, as well as an interest and need for meaningful activity and creativity in general. Teacher training has a significant impact on the quality of education. Updating teachers' knowledge is not only important in vocational subjects. No less it is also necessary to improve their mental skills. Teachers are exposed to time pressures, demands on decision-making processes, conflict resolution, managing professional tasks, communicating with superiors, colleagues and parents. For these reasons, there is a significant need for teacher self-development programmes.

Understanding emotions, their importance in life management and consciously working with them will help educators to manage and cope with these situations. Deepening self-awareness brings the ability to understand other people. Increasing their capacity for empathy will also enable them to develop empathy in their students. By gaining self-esteem and self-confidence, the educator can also find ways and willingness to support pupils, parents and colleagues. Improving social awareness allows for a more effective influence on others. A deeper understanding of motivation and its impact on success helps to use this knowledge to motivate students more effectively in education. The essence of the modern understanding of the educational process is activity, independence and creativity. Emotionality, intelligence and mental resilience are complementary. The main objective of the proposed teacher education programme is to acquire knowledge and improve professional competences in the field of individual components of emotional intelligence and psychological resilience and to be able to use them in pedagogical activities.

1.1. The Research Area Current State of Research

Key competences are a set of knowledge, skills, competences and attitudes of value that enable an individual to know, act effectively, evaluate, communicate and understand, integrate into social relationships and develop as a person. It is thus the ability to apply one's education in work, family and personal life. These competences are formed gradually, because of personal practical activity and experience, and are applicable in practical life. At the same time, they also change in quality and value throughout life, have the potential for continuous development and are a source of personal flexibility.

By guiding, supporting and reinforcing reflection, the teacher will improve his/her ability to learn more autonomously, to perceive his/her personal potential and to take responsibility for his/her own learning and self-development. The use of activating, interactive teaching methods is a prerequisite for the effectiveness and implementation of literacy development, including social and emotional literacy. The choice of how and when to implement the development of individual literacies is the responsibility of the school. The above principles are respected in the development of our methodological guide in applied research. The alarming increase in the number of people at risk of risky behaviour, depression, violence, various forms of addictive behaviours, as well as disinterest in culture, is related to fundamental deficiencies in the educational, or educational, especially relational, environment (Madarasová Gecková, Husárová et al., 2023; Cefai et al., 2021; TTS, 2024). Both psychology and current neuroscience findings confirm that there is a typical, ontogenetically innate tendency for humans to relate specifically to close and trusted people, to seek mutual unity and understanding with other people, and to seek meaning and deeper significance in their being, life, and the world around them (Shotter, 2017; Cozolino, 2014; Gergen, 2009). Psychological resilience has also been explored in the global scientific and professional literature in relation to issues of emotionality and sociability.

2. THEORETICAL BACKGROUND

2.1. Emotions

Perceiving emotions and thinking about them is essential for emotional regulation. Emotion regulation is aimed at maintaining, strengthening, or suppressing emotions and their expression. If emotions are excessively suppressed, a certain emptiness and distance is created. Conversely, if they get out of control and are exaggerated, they can become morbid and bothersome. The ability to keep emotions under control is the key to a satisfying

emotional life. Emotion regulation is the process by which an individual influences what emotions he will have, how he will experience and express them. With the help of emotion regulation, it is possible to achieve that a person remains calm in stressful situations, knows how to defend himself against feelings of fear and quickly regenerates after negative feelings.

According to (Schulze & Roberts, 2007), self-regulation can be perceived as a form of problem solving with the aim of mitigating the difference between reality and the target value of a given internal state. In this case, teachers' self-regulatory activities aim to change the current emotional state to the target state.

According to Martinčková (Martinčková, 2012), the main components of self-regulation are Reliability - the ability to observe the basic rules of propriety. Conscientiousness - the ability to take responsibility for one's own behaviour and performance. Adaptability - the ability to adapt to change. Innovativeness - the ability to be open to innovation and to generate new ideas. Self-regulation is based on the knowledge that people are capable of managing their own feelings and internal processes. In this way they can learn to deal with emotionally charged situations. According to Marman (Marman & Jurásek, 2014), there are three key areas that need to be developed: Get rid of your fear. Promote your strengths. Be more receptive every day.

It is good to know the influence of a particular emotional experience on motivation and will, on achieving success, for example how positive and negative emotions affect the way we think and the way we solve problems. If he can recognise his own feelings, define his needs and set goals, he can work better with his emotions. As stated by (Kaliská & Salbot, 2011), the ability to recognise mood, temperament, motivation, other people's needs and the appropriate way to respond to them is at the heart of interpersonal intelligence, i.e. the intelligence of interpersonal relationships. On the other hand, access to one's own feelings, the ability to identify and use them in one's decisions and actions. Emotional intelligence can change with experience and learning. Emotional regulation is an important part of EI. It is the process by which an individual influences what emotions he or she will have, how he or she will experience them and how he or she will express them.

2.1.1. Emotional Regulation Strategies

Emotional regulation strategies relate to the experience of emotions and are focused either on the prerequisites for the emergence of emotions or on the manifestations of emotions themselves. Garnefski and Kraaij (2014) identified a total of 9 strategies for cognitive regulation of emotions - self-blame, acceptance, thinking, positive focus, planning, positive reappraisal, judging in context, catastrophizing and blaming others. When developing emotional regulation, it is necessary to focus on strengthening strategies that positively affect our emotional experience. They are mainly acceptance, positive focus and assessment in context. A suitable strategy is to accept the inevitability of negative emotions and assess them in context, i.e. knowing that even negative emotions contain valuable information that can help a person to act effectively. Inappropriate strategies are, for example, passivity and self-blame, when the individual does not take into account his needs and experiences, or, on the contrary, aggression and blaming others, when the individual expresses his emotions without inhibitions verbally and non-verbally.

It is possible to regulate the experience of emotions and reach the target state more easily with the help of training. Pletzer has developed several methods of emotional regulation (Pletzer, 2009): visualising the target state, eliminating stereotypes and breaking bonds, leaving the comfort zone, registering negative feelings and activating positive ones, imagining feelings, judging from a distance, changing the point of view, awareness of responsibility for one's own feelings. Emotional regulation in the teaching profession has a

significant impact on the educational and pedagogical outcomes of their work. On the one hand there is self-regulation, when teachers consciously work with their own emotions, and on the other hand they influence the emotional development and motivation of pupils and students. The goal of emotion regulation in educators should be the ability to manage their emotions so that they can better cope with stressful situations, eliminate negative experiences, and actively use emotions in the learning process. Perceiving and influencing other people's emotions is an interpersonal competence in the construct of emotional intelligence.

In developing emotional regulation, it is necessary to focus on strengthening strategies that positively influence our emotional experience. These are mainly acceptance, positive focus and judging in context. An appropriate strategy is to accept the inevitability of negative emotions and to evaluate in context that even negative emotions contain valuable information that can help a person to act effectively. Inappropriate strategies are, for example, passivity and self-blame, where the individual does not take into account his or her needs and experiences, or, conversely, aggression and blaming others, where the individual makes his or her emotions known uninhibitedly, both verbally and non-verbally. The experience of emotions can be regulated and through training it is easier to reach the target state (Pletzer, 2009).

2.2. Resilience

In psychology, the concept of resilience has evolved from being understood in terms of a specific personality characteristic to a multi-component concept and the inclusion of internal and external protective factors. Currently, several research teams around the world are investigating psychological resilience (Ungar, 2021; McMahon, 2015; Olsson, Bond, Burns, Vella-Brodick, & Sawyer, 2003). However, more recently, there is a call to examine it comprehensively as a culturally contingent construct and to integrate a social-ecological perspective (Ungar, 2021; Twum-Antwi, Jefferies, & Ungar, 2020; Pettoello et al., 2019; Zolkoski & Bullock, 2012).

Psychological resilience has been characterized by the ability to bounce back from negative emotional experiences and by flexible adaptation to the changing demands of stressful experiences (Block & Kremen, 1996; Lazarus, 1993). This definition captures a psychological frame of mind that is associated with a variety of behavioral and psychological outcomes. A convergence across several research methodologies indicates that resilient individuals have optimistic, zestful, and energetic approaches to life, are curious and open to new experiences, and are characterized by high positive emotionality (Block & Kremen, 1996). Resilience is one of the important components in the character area of the educational standards. The overall aim within the resilience component is to guide teachers to be resilient and steadfast in their own actions, so that they are able to persevere in their decision to do well, overcoming external obstacles and internal negative tendencies, and strengthening their own orientation to the meaning of their actions.

By strengthening the system of psychological resources for resilience (Ungar & Theron, 2020), the teacher will be able to be specifically aware of and understand his/her feelings and emotions as an integral part of his/her perception and experience. Teachers will be able to recognise their necessary function in different activities. They will learn to identify them better and gradually acquire appropriate ways of expressing them, including their socially meaningful expression and interest in other people's experiences and needs and in communicating and cooperating with them. Teachers will also become more aware of their own potential and the need for planning. Teachers will be able to communicate openly and in a socially respectful manner, they will learn techniques for conflict avoidance and constructive and non-violent conflict management. It would improve teachers' ability to act

responsibly with regard to the rights, freedoms and needs of others. Teachers should therefore become more aware of the need for constant self-awareness and self-reflection for their own development and growth, and thus be freer and more socially responsible in the formation of their personal identity and integrity.

The overall objective of the project is precisely to develop a structural-interaction model of resilience (Ungar & Theron, 2020), based on the current theoretical paradigm of knowledge of the concept of resilience, applicable in school settings. This model is intended to describe the essential content and relational characteristics of resilience at different levels in general or in different contexts, while allowing the implementation of new knowledge in the educational process, without compromising the internal integrity of the model and its practical effectiveness. With regard to the structure of the concept of psychological resilience, it is first necessary to identify the basic building blocks of the model, its components. At the most general level, these components include (Ungar & Theron, 2020): risk factors for maintaining resilience, specific resilience factors, and the feedback consequences of the interaction of these factors (their effect on the individual's behaviour and survival).

According to Ungar and Theron (2020), the components of resilience represent the general domains of the resilience structure and give it shape; the elements represent the specific content of the individual attributes of resilience (e.g. optimism, personal efficacy, social competence as personality traits, peer ties and relationships, open communication in the family, as internal and external domains, etc.).

The International Resilience Research Centre (<https://resilienceresearch.org/>) is developing new methodologies for the study of resilience, using integrative designs, exploring specific cultural and contextual processes and anchoring constructs, as well as methodologies for their application. The present targeted applied research project draws on the above-mentioned recent findings from several scientific fields in relation to emotionality, social interaction and resilience.

2.3. Interventions and Learning Programs

Researchers aim to provide insights into the resilience that exerts its protective function, with a view to using these insights in the design and implementation of intervention programmes aimed at promoting resilience and preventing the psychopathological consequences of stress. Given the dynamic, processual and contextual nature of resilience, interventions aimed at enhancing resilience need to be equally dynamic, flexible and socio-culturally specific. It is crucial that feedback loops are in place so that evidence from interventions can feed back into research and theory (Vancu, 2024).

Luthar and Cicchetti (2000) developed the methodological requirements for an intervention based on resilience research: a theoretical and research base based on the observation of a specific target group. The intervention should not only aim to eliminate negative manifestations, but also to promote positive adaptations and competences. The intervention should be designed to reduce negative manifestations and take advantage of specific opportunities within the group. Take into account developmental aspects according to the age of the target group. Confrontation of the effect of the intervention with scientific methods. In order to prevent the negative consequences of stress in the school environment, A. E. Kazdin (2002) recommends the use of coping programmes. A. A. Hains (1992) highlighted the benefits of cognitive-behavioural stress management. In adolescents who participated in cognitive-behavioural stress management programmes, the effect of the programme in reducing the negative consequences of stress in various stressful events was confirmed in students and teachers. Effective prevention programmes include the Ellis Multifactorial Comprehensive Prevention Programme (Hall, 2002). It emphasises the need

to provide information on self-evaluation, positive thinking and building meaning in life. An example of a specific effective cognitive-behavioural programme is 'Coping with Depression' (Hall, 2002), and school-based stress management prevention programmes directly applied in schools (Kraag et al., 2006). Attention is paid to positive personality development. This is a direction that seeks to rapidly translate the results of longitudinal studies into practice in the form of interventions (Catalano, Berglund, Ryan, Lonczak, & Hawkins, 2004).

In the UK, Resilience Teaching has been introduced, which focuses on revising cognitive appraisals of different stressful situations based on the experience of successfully overcoming obstacles and stressful situations in different domains (CPP: <https://ppc.sas.upenn.edu/>). An Australian programme with a similar focus focuses on the cultural context of resilience (Lemerle & Ildes, 2004) - the Brita Programme: Building Resilience in Transcultural Peoples and Coping with Stress - The Best Coping (Frydenberg, 2004).

M. T. Greenberg, C. Domitrovich, & B. Bumbarger (2001) also looks at the prevention of mental disorders. In a review of available primary prevention programmes abroad, they consider preventive intervention to be an important element in reducing symptoms of psychopathology or factors commonly associated with increased risk of developing mental disorders. They examine the general characteristics of prevention programmes and make recommendations for their practical use in schools and community groups. The authors (Greenberg et al., 2001) list the following as effective stress management programmes Anger management programme, Coping with stress course, Counsellor care, Coping and support training, Improving social awareness - social problem solving, Interpersonal cognitive problem solving, Peer coping skills training, Promoting alternative thinking strategies, Primary mental health project, Social relations programme, Stress inoculation training I, II.

Research in education, training and personal development points to the need to use groups of methods in conjunction with each other to more effectively strengthen a person's coping resources and psychological resilience. Resilience is closely related to an individual's overall quality of life, as it is involved in maintaining mental and physical health. According to (Kaliská & Salbot, 2011), resilience changes and develops throughout an individual's an individual's life and can be built and supported.

2.3.1. Requirements for Teacher Competencies

School is an important institution of socialisation that fulfils four basic goals - educational, professional, social-civic and personal (Zeřová, 2007). The effectiveness of the educational process depends on the characteristics of the learner, the teacher, the learning material and the learning conditions. Emotions are a natural part of the educational process. Their sources are related to all aspects of school life, the learning process and relationships between teachers, students and parents (Zeřová, 2007).

All these areas can be a source of both positive and negative emotions. The predominance of positive emotions is likely to be reflected in teachers' performance. As he further states, pleasant emotions such as joy, self-satisfaction and satisfaction can be associated with success, mastering tasks and problems, recognition and appreciation, and gaining respect (Hlinková, 2014).

The teacher has an irreplaceable role and responsibility in creating a pleasant emotional atmosphere in the classroom. Among the main requirements for the teacher in the context of developing the emotional intelligence of the students are personal maturity, appropriate social skills, sensitivity and receptivity, the ability to accept the individual peculiarities of the students in the field of experience and behaviour (Salbot, 2011).

An important element of a teacher's work is communication with the parents of pupils. The teacher should try to get the parents to cooperate. Gaining the parents' trust and establishing good cooperation requires certain skills, social and communication skills of the teacher. The teacher encounters situations where family relationships are problematic and the child's behaviour is negatively affected. The teacher also encounters parents who shift a large part of the responsibility from the child to themselves or who overestimate their child (Hlinková, 2014).

Sometimes parents behave inappropriately, aggressively, offensively. It is necessary to prepare for the meeting with the parents so that the teacher can argue objectively and create a friendly atmosphere. Training in verbal and non-verbal communication, which determines the effectiveness of the meeting, can be of great help. The third area is relations with colleagues and superiors. The teacher should contribute to a positive working atmosphere, encourage cooperation in the exchange of experience, offer and seek help when needed. Assertiveness, creativity and initiative will be important in this area. Schulze and Roberts (2007) suggested that pre-service and in-service teacher education should include topics that address the need to support the development of emotional intelligence in schools.

As stated by (Schultze & Roberts, 2007), educators need a broad repertoire of knowledge, methods and professional experience in using emotional intelligence in learning and performance situations. Emotional skills can contribute to improving the quality of cognitive functioning and intellectual behavioural outcomes, in particular by improving decision-making processes, self-management and stress regulation. Teachers themselves are aware of the importance of self-awareness and self-reflection for successful teaching and the need to improve communication skills. In this vein, Salovey and colleagues (Salovey & Mayer, 1990) described emotional intelligence as the ability to monitor one's own and others' feelings and emotions, to discriminate among them, and to use this information to guide one's thinking and actions. It is important to note that there are individual differences in the ability to process this information and use it to one's advantage in coping with negative circumstances.

It is possible, then, that emotional intelligence plays a significant role in the lives of resilient people. Specifically, what might distinguish low and high-resilient people is their capacity to learn from life's setbacks and use this knowledge to cope more effectively (Salovey, Bedell, Detweiler, & Mayer, 1999). Given the evidence showing that positive emotions indeed produce beneficial outcomes in the coping process (e.g., Folkman & Moskowitz, 2000; Fredrickson, 2000) and that certain individuals are more adept at using emotion knowledge to cope in times of stress (e.g., Barrett & Gross, 2001; Salovey, Hsee, & Mayer, 1993), it is possible that certain individuals have a greater tendency to draw on positive emotions in times of stress, intuitively using positive emotions to their advantage. Psychologically resilient people—who are described as emotionally intelligent (Salovey et al., 1999).

3. OBJECTIVES, DESIGN AND METHODS

3.1. Focus and Description of the Project

The interdisciplinary research project focuses on the main target areas which are the development of specific competences of the teachers in the context of cross curricular literacy of the National Curriculum for Primary Education.

As part of the project there will also be sub-improvements such as:

Development of a new methodology - a working textbook for strengthening the component of resilience and developing social and emotional literacy of pupils of the first stage of primary school and the conditions of primary education.

Compilation of a (digitalised) methodological manual for the implementation of the methodology in school conditions for teachers as target group of the applied research project. Develop a new methodology for the target group of the applied research project. Developing a short training programme for teachers to learn the methodology, including e-learning and webinars. In the future, it would be appropriate to create an open online and offline system for continuous quality monitoring and improvement of the educational modules of methodology, continuous communication and interactive learning for participating teachers in the new state educational programme.

3.2. Design and Methods

Based on knowledge and theoretical studies, we have developed a training programme for teachers that focuses on the adoption, implementation and evaluation of the methodology for improving interpersonal communication skills, developing emotional intelligence and resilience. As part of the preparation, we approached teachers to find out their views on the importance of teacher preparation in the area of emotional intelligence skills. This included a short 4-question questionnaire, which we used to test the assumption that teacher training in emotional intelligence is important and insufficient. The sample consisted of school teachers. A total of 98 teachers were contacted. The answers could be recorded on a scale from 1 to 4 with the values not at all (1), weak (2), average (3), very good (4). The assumption of the need to supplement the training of teachers in this area was confirmed.

3.3. Objectives of the learning program

The main objective of the training programme is to acquire knowledge in the field of individual components of EI with emphasis on self-regulation, interpersonal skills, to understand them and to improve professional competences of teachers so that they can use them in pedagogical activities for personality development.

The main objective of the training programme is to acquire knowledge and skills in the field of emotional intelligence and psychological resilience (Table 1).

*Table 1.
Specific objectives of the education and training programme.*

To understand the essence and importance of emotionality for managing one's own way of life and achieving life satisfaction.
Deepen self-awareness, recognise responsibility for one's own emotional experience and learn ways to support this in one's students. Improve the ability to manage anger, anxiety and fear.
Understand motivation more deeply and use this knowledge to motivate students more effectively.
Increase the capacity for empathy in yourself and your students.
Improve social awareness and understanding of pupils' behaviour and be able to identify its possible causes.
Understanding and respecting the attitudes and opinions of others, the ability to give and receive feedback.
Improve non-verbal and verbal communication, presentation and negotiation skills. • Know how to resolve conflicts and settle disputes more effectively.
Understand group processes and know how to use them in practice.
Be able to build trust and openness in interpersonal relationships, understand the importance of being able to give help as well as to accept or ask for help.
Know how to use acquired skills to innovate in the educational process.
Apply the basic principles of a healthy lifestyle in everyday life.

4. THE IMPLEMENTATION AND RESEARCH DIRECTIONS

In designing the programme, we placed great emphasis on the practical side of the training, which is still lacking in the psychological preparation of teachers. The thematic plan of the modules and the suggested exercises are exemplary, and the lecturer can modify or supplement them according to his own knowledge and experience. It is important to keep the practical part and a certain playful form of exercises and teaching. The aim is for teachers to be able to understand the different components of emotional intelligence and, above all, to be able to use them for the development of their pupils.

The programme has been designed with the intention of applying emotional intelligence in the teaching profession. The total duration of the programme - 120 hours (the practical part of the programme is designed in the scope of 98 hours).

The training programme is designed for in-service training of primary and secondary school teachers. The schedule of the curriculum according to the individual topics and the allocation of teaching hours was as follows: characteristics of emotionality 12 hours, emotional intelligence 23 hours, resilience 20 hours, empathy 21 hours, social skills 15 hours, communication skills 18 hours, emotionality in the teaching profession 11 hours. The programme is designed so that the different areas build on each other. The programme has been designed with a strong emphasis on the practical side of training, which has been lacking in the psychological training of educators.

We have designed the programme so that the modules build on each other, while at the same time allowing knowledge to be deepened and consolidated through repetition. In the first part of the programme, which focuses on intrapersonal skills, a significant part of the training is devoted to self-awareness, self-regulation and resilience. Teachers will gain knowledge on how to develop these constructs, impulses and motivation for self-management. The second part of the programme focuses on interpersonal and communication skills. Teachers will have the opportunity to compare the content of the lectures with their practical experience as they use these skills in their work every day.

The programme should teach them to work efficiently, constructively and with interest. The aim of the proposed programme is that teachers, after additional training, will understand the different components of emotional intelligence and, more importantly, be able to use them for their own development and that of their pupils. A programme for teachers is currently being implemented in a number of schools. The importance of implementing this type of programme is demonstrated by the ongoing results and feedback from teachers about the programme.

5. CONCLUSION

We have developed an intensive short-term training programme for teachers, aimed at the acquisition, implementation and evaluation of the developed methodology (mentor teachers). The programme has been designed with a strong emphasis on the practical side of the training, which is still lacking in the psychological training of educators. The thematic plan and the exercises with activities can be adapted or supplemented by the trainer on the basis of his/her own knowledge and experience. It is important to maintain the scope of the practical part and a certain playfulness of the exercises. The aim is that, after the training, teachers will understand the different components of emotional intelligence and, in particular, be able to use them for their own development and that of their pupils.

The programme has been designed with the application of emotional intelligence in the teaching profession in mind. The programme has been designed so that the modules build on each other and also so that knowledge is extended and consolidated through repetition. In the first part of the programme, which focuses on intrapersonal skills, a significant part of the training is devoted to self-awareness, self-regulation and resilience. Teachers learn how to develop these constructs as well as the impetus and motivation for self-management. The second part of the programme focuses on interpersonal and communication skills.

In the future, it would be advisable to create an open system of continuous quality monitoring and improvement of the pedagogical modules of the methodology, using a dedicated website with dialogical/interactive components and innovative digitized content. Finally, it would be appropriate to create a comprehensive digitized methodology handbook for teachers. Methodology for teachers, based on an empirically validated theoretical model and practical research on the effectiveness of using the methodology to develop and strengthen the psychological resilience component and social and emotional literacy.

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Chapter # 34

HOW DO STUDENTS MANAGE CHALLENGING STUDY TASKS?

A Thematic Analysis of Higher Education Students' (Non-)Strategic Study-related Behaviors*

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ABSTRACT

Higher education presents students with numerous challenges, requiring effective use of executive functions (EFs) to navigate academic demands. EFs are higher-order cognitive processes that regulate thinking, behavior, and emotions for goal-directed and adaptive actions. While strategic behaviors can optimize EFs, students also adopt routines or habits (non-strategic behaviors) to manage study tasks. This study explores students' (non-)strategic behaviors and which EF they predominantly support. Twenty-three students (aged 17-26) were interviewed at a Dutch University of Applied Sciences. Subsequently, we identified 27 themes and 89 types of (non-)strategic behaviors linked to nine EFs through inductive and deductive thematic analyses. The findings provide insights into which specific (non-)strategic behaviors support EFs. This helps students and educators identify behaviors that can strengthen particular EFs, especially those that may be underdeveloped and offers input for guidance for more targeted educational interventions to improve learning and studying.

Keywords: challenging study tasks, executive functions, higher education, study-related strategies, thematic analysis.

1. INTRODUCTION

Students entering higher education encounter numerous challenges, including new learning methods and increasingly complex subject matter, compounded by performance pressures such as exams (Meltzer, Greschler, Davis, & Vanderberg, 2021). These challenges require students to employ strategies to overcome them, activating their executive functions (EFs). EFs encompass higher-order neurocognitive processes involved in the top-down control of behavior, emotion, and cognition (e.g., Diamond, 2013; Nigg, 2017). This study explores students' strategic and non-strategic behaviors, supporting their EFs.

2. BACKGROUND

Executive functions (EFs) include inhibition, working memory, cognitive flexibility, planning, organizing, and initiation (e.g., Baggetta & Alexander, 2016; Gioia, Isquith, Guy, & Kenworthy, 2000). EFs are cognitive processes primarily employed at the onset of new situations that require knowledge acquisition or skill rehearsal (Naglieri & Otero, 2014). Consequently, EFs and learning are closely intertwined, as evidenced by their relationship with self-regulated learning (Garner, 2009; Musso, Boekaerts, Segers, & Cascallar, 2019; Pinochet-Quiroz et al., 2022) and academic success (Baars et al., 2015; Denckla & Mahone, 2018; Manuhuwa, Snel-De Boer, Jaarsma, Fleeer, & De Graaf, 2023). While deficiencies in EFs can make it harder to tackle challenging study tasks, the right interventions can help overcome these difficulties (Zelazo, 2015).

Students can support their EF by employing strategies or 'strategic behaviors'. Strategic behaviors are effortful, goal-directed actions using knowledge and skills stored in long-term memory (Van Meter & Campbell, 2020). Strategic behaviors supporting EFs – 'EF strategic behaviors' - in education include for instance, behaviors to support and access working memory, such as note-taking or remembering to bring necessary material from school to home (Meltzer et al., 2021).

EF strategic behaviors are learned and developed implicitly, through daily life experiences, and explicitly, through formal education. For instance, students might learn problem-solving skills implicitly from parents or explicitly from teachers who, in their own ways, both encourage independent thinking and perseverance (Barkley, 2012). Research shows that explicitly teaching students EF strategic behaviors is beneficial across all educational levels, including higher education (e.g., De Boer, Donker, Kostons, & Van der Werf, 2018; Diamond, 2014; Meltzer et al., 2021). EF strategy use broadly correlates with overall academic success (e.g., Meltzer et al., 2021; Sebesta & Speth, 2017). They help students learn more effectively and increase their ability to adapt strategies to match specific task demands (Schneider, 2010). While the importance of explicit strategy instruction in education is recognized, consistent and systematic implementation remains a challenge across educational contexts (e.g., Draper & Cevalco-Trotter, 2023; Meltzer et al., 2021).

Students also adopt behaviors supporting their EFs that are not considered strategic, as they lack goal-directed actions or significant effort. Examples include actions such as drinking coffee to stay alert, taking walking breaks, or setting reminders in a planner. While sometimes purposeful, these behaviors require minimal effort and complexity. In this study, we refer to such behaviors as 'non-strategic' behaviors.

3. RESEARCH GAP AND QUESTIONS

Although employing various (non-)strategic behaviors to support executive functions (EFs) may benefit academic success, there is limited understanding of how students manage complex study tasks in daily life and how these behaviors support their EFs. This gap calls for studies focusing on students' perceptions and experiences concerning their strategies to deal with complex study tasks to enhance EF support in higher education.

The research questions are:

1. What (non-)strategic behaviors do higher education students employ to manage new and complex study tasks?
2. Which executive functions are supported by these (non-)strategic behaviors?

4. METHODS

4.1. Research Methodology

This qualitative study uses a hybrid approach, including inductive (step 1; research question 1) and deductive (step 2; research question 2) thematic analyses. Thematic analysis is a non-linear and iterative process that recognizes, examines, and communicates patterns (i.e., themes) within data (Braun & Clarke, 2019). In step 1, we applied an inductive data-driven approach exploring the raw data for meaningful descriptions of the subjective student-reported (non-)strategic behaviors to challenging study tasks. Subsequently, in step 2, these (non-)strategic behaviors were evaluated qualitatively by experts and categorized into specific EFs, following a theory-driven approach based on the theoretical framework of Gioia et al. (2000). However, given the fact that the study was conducted in a Dutch context, we supplemented this framework with Scholte and Noen's (2011) framework, which includes nuanced adjustments to the operationalizations tailored to the Dutch context, ensuring cultural and linguistic relevance. Scholte and Noens (2011) used the following operationalizations for EF:

- *Inhibition*: the ability to control impulses and stop actions at appropriate moments, essential for managing social and task behaviors;
- *Flexibility*: the ability to adapt to changes, shift focus, and solve problems in dynamic contexts;
- *Self-Monitoring*: the awareness of one's behavior and its impact on others to ensure socially appropriate actions;
- *Initiation*: the ability to independently start tasks or generate ideas without external prompts;
- *Working Memory*: the capacity to retain and use information for completing multi-step tasks and following instructions;
- *Planning and Organization*: the ability to set goals, create strategies, and organize materials to complete tasks efficiently;
- *Task Monitoring*: maintaining awareness of progress, identifying errors, and ensuring successful task completion;
- *Emotion Regulation*: the ability to manage emotional responses and avoid disproportionate reactions;
- *Orderliness*: organization of physical spaces to maintain efficiency in daily activities.

4.2. Participants

Students of a University of Applied Sciences were recruited through invitations sent by email and during lectures. Participants were purposefully sampled, and to ensure symbolic representation, we included only higher education students aged between 17 and 26, focusing on young adults. No restrictions were placed on the students' academic year or field of study to ensure diversity. However, diversity was considered a secondary selection criterion, monitored but not prioritized.

This process resulted in a sample of 23 students (mean age 22.48 years, $sd=2.48$; male 52%, female 48%; education: Applied Psychology 73.9%, Creative Media and Technology 21.7%, and one student Human Resource Management).

4.3. Data Collection

The interviews took place in November and December 2021, face-to-face and online, and lasted an average of 85 minutes. Twenty students were engaged in dyadic or group interviews with six to eight students. These interviews have the advantage that the interaction allows participants to share, compare, and refine experiences (Morgan, 1996). Due to practical limitations, three students were interviewed individually. Individual interviews offer deeper insights and allow more unrestrained expression without group influence, resulting in richer data (Patton, 2015).

The interviewers followed a semi-structured guide (see Supplementary 1 for additional information; please refer to the link: <https://doi.org/10.17026/SS/XWJRCC>). Each interview started with an introduction to the topics that would be explored. Next, the students were asked probing questions about written vignettes that set out challenging study tasks that all students typically face. The interviewers were instructed to start with prestructured queries and follow the students' line of thinking as much as possible, using both open and guiding questions.

4.4. Ethical Protocol

The study was pre-approved by an Applied University ethical advisory committee (SEAC-2019-14 B). Students received information and signed an informed consent.

4.5. Data Analyses

The interviews were audio-recorded using MS Teams, transcribed verbatim, and thematically analyzed using Atlas.ti software v22, Microsoft Excel, and Microsoft Word.

For the first research question, we employed Braun and Clarke's reflexive thematic analysis (RTA) to explore patterns in the data (Braun & Clarke, 2019). This inductive approach allowed themes to emerge naturally from the participants' reported experiences without being constrained by predefined categories or theoretical frameworks. This aligns with Braun and Clarke's constructivist and interpretivist paradigm, which values the subjectivity of researchers as an integral part of the analytic process. Themes were developed through iterative discussions and reflexive engagement with the data involving DM, SH, and JS. Following an initial calibration session, each researcher independently coded text fragments or sentences and assigned labels reflecting the essence of each behavior (i.e., quotation). Subsequently, these codes were then clustered into themes through collaborative discussions. Any discrepancies in interpretations during the coding process were resolved through further discussions. The subjective nature of this phase meant that we did not aim for inter-rater reliability, as it is not consistent with the principles of RTA (Braun & Clarke, 2019). Instead, we prioritized coherence and depth in the interpretative process. The resulting themes represent a co-constructed understanding of the data, shaped by the researchers' reflections and interactions with the participants' narratives.

Given the study's exploratory nature, we aimed for sufficient information power rather than data saturation (Varpio, Ajjawi, Monrouxe, O'Brien, & Rees, 2017). The concept of information power posits that the greater the amount of relevant information held within the study's sample, the fewer participants are required (Malterud, Siersma, & Guassora, 2015). Adequate information power depends on several dimensions: (1) the objectives of the study, (2) the specificity of the sample, (3) the incorporation of established theories, (4) the quality of interaction, and (5) the approach to analysis. We aim to meet at least four of these dimensions: (1) a focused scope, specifically exploring supportive EF (non-)strategic behaviors in higher education; (2) a specific target group of young adult higher education students; (3) a theoretical framework, in our study the EF framework, which served as the

foundation for the deductive part; (4) a high-quality dialogue, achieved through in-depth interviews, and (5) a cross-case analysis searching for different (non-)strategic behaviors and common themes.

We adopted a theory-driven, deductive approach to thematic analysis for the second research question. Using Gioia et al.'s (2000) theoretical framework, supplemented by Scholte and Noens's (2011) Dutch operationalizations of EFs, we aimed to assign the (non-)strategic behaviors identified in the first phase to specific EFs. This deductive phase applied a predefined coding framework to ensure alignment with established theoretical constructs.

Unlike the inductive approach for RQ1, this phase required a structured process to calibrate interpretations among researchers DM, SV, and JG. Although Braun and Clarke's RTA (2019) discourages inter-rater reliability for exploratory coding, we incorporated calibration sessions to enhance the consistency and transparency of our deductive coding. These sessions ensured that the operational definitions of EFs were applied uniformly while maintaining space for interpretative depth. Our hybrid approach bridges Braun and Clarke's method's flexibility with the pragmatic need for transparency in the deductive coding process. It allowed us to systematically analyze how specific (non-)strategic behaviors support particular EFs while preserving the data's complexity and richness. See Supplementary 1 for additional information; please refer to the link: <https://doi.org/10.17026/SS/XWJRCC>.

5. RESULTS

Table 1 presents the results of the study related to both research questions, namely:

RQ 1: 'What (non-)strategic behaviors do higher education students employ to manage new and complex study tasks?' and

RQ 2: 'Which executive functions (EFs) are supported by these (non-)strategic behaviors?'

The first column of Table 1 provides a comprehensive overview of the themes derived from students' reported (non-)strategic behaviors. Column 2 contains the found (non-)strategic behaviors, where one or more literal student quotations are summarized as statements for clarity and conciseness. Column 3 refers to the results related to RQ 2, indicating which EF is predominantly associated with each (non-)strategic behavior. Finally, for a detailed overview of these themes, (non-)strategic behaviors, executive functions, and example quotations, see Supplementary 2; please refer to the link <https://doi.org/10.17026/SS/XWJRCC>.

Table 1.
Themes, statements (non-)strategic behaviors, and corresponding executive function.

Theme	Statement (non-)strategic behavior	Supporting the Executive Function
Annotating involves finding and highlighting the content's essential ideas or key messages.	I highlight key sections in the text.	Working memory
	I distinguish between main and secondary issues.	Organization

Theme	Statement (non-)strategic behavior	Supporting the Executive Function
Assertive communication is about setting boundaries to get your tasks done.	If I want to study quietly, I ask others not to bother me.	Working memory
	If I think the quality of the learning environment is poor, I express my opinion to a lecturer.	Flexibility
Attention regulation involves optimizing one's mental state to improve concentration.	I take a break to help me feel more alert or calm down, a break where I do nothing, go for a walk, take a nap, shower, or play games.	Flexibility
	I put on some sound, a YouTube walking tour, or music to help me concentrate better.	Working memory
	I do not play music because it distracts me.	Inhibition
	I use tools like apps or a kitchen timer to help me focus for a certain period.	Working memory
	I take substances, like caffeine or medication, to help me concentrate.	Working memory
	I start working at times when I can concentrate better than at other times.	Working memory
	I take good care of myself (like getting enough sleep, eating and drinking properly, and exercising) to manage and sustain my study tasks.	Planning
Checking work refers to looking closely at a completed task to verify if all requirements are met.	I check my work before handing it in to ensure it is complete.	Task monitoring
Coping with stress refers to coping mechanisms.	When I get emotional, I accept it.	Emotion regulation
	When problems arise, I step back and look at the situation from a different angle.	Flexibility
	When I feel stressed, I consciously let my thoughts pass by to help me relax.	Emotion regulation
Coping with changes in study tasks.	I am flexible if a study task changes, such as an adjustment to the assignment.	Flexibility
	If something changes, like an assignment change, I carefully consider how much more energy I want to put into it.	Flexibility
Coping with failure refers to dealing with a lack of success through (un)helpful thoughts.	I accept that failure is part of the process and is not a disaster if things occasionally go wrong.	Emotion regulation
	I think avoiding failure is best, so I quit early or did not even begin the study task.	Emotion regulation

How Do Students Manage Challenging Study Tasks? - A Thematic Analysis of Higher Education Students' (Non-)Strategic Study-Related Behaviors

Theme	Statement (non-)strategic behavior	Supporting the Executive Function
Creating an overview by structuring and prioritizing information to get a clear picture.	I ensure I get an overview of everything I need to do.	Organization
	When I begin a study task, I review what I must do, including the assessment criteria and deadlines.	Planning
Elaboration refers to adding more detail or information to enhance understanding and memory of a concept or idea.	I ask myself in-depth questions to check what I know about the subject or form my opinion.	Working memory
	I delve into the subject matter by discussing it with others.	Organization
	I learn by explaining the subject matter aloud to myself or others.	Working memory
Following structure refers to adhering to a provided structure.	I attend all the lectures for a course.	Organization
	I do the assigned homework.	Organization
Internal self-talk refers to having encouraging or reassuring thoughts.	I talk to myself in a reassuring way.	Emotion regulation
	I tell myself encouraging things.	Emotion regulation
Lecturer support refers to seeking or asking for a lecturer's support.	I study near a lecturer, which motivates me to get to work.	Initiation
	I ask my lecturer for feedback on, for example, an assignment I have done or a schedule.	Task monitoring
	I ask the lecturer questions about the subject matter.	Organization
Managing distractions involves handling internal distractions. This could vary from ignoring them to giving in.	I ignore distractions around me, like a mobile phone on the table or people talking.	Inhibition
	I ensure that no external distractions are near me or avoid them altogether.	Inhibition
	If I catch myself having distracting thoughts, I get back to the task at hand.	Inhibition
Memory support involves using one or more methods to help retain and recall study material.	I use memory techniques such as mnemonics and incorporating humor.	Working memory
	I retain study material by repeating it frequently or by engaging with it extensively.	Working memory
	I remember study material or tasks by writing them down or recording them as voice notes.	Working memory
	I assume that I will automatically remember important study material.	Working memory
Managing the environment involves organizing and optimizing the	I tidy my work area before starting a task, such as organizing my desk or computer folders.	Organization
	I ensure I have suitable materials for studying, such as a laptop or a notepad.	Organization

Theme	Statement (non-)strategic behavior	Supporting the Executive Function
environment to carry out a study task effectively.	I have set up a workspace I use exclusively for studying, associating it with study time.	Organization
Organizing learning refers to structuring study content and tasks to help simplify the complex amount of information or tasks.	I structure my notes by, for example, creating a diagram or showing connections with lines.	Organization
	I break my tasks into smaller sub-tasks.	Organization
	I visualize how the learning material is structured by creating a mind map, for example.	Working memory
Peer support involves learning through interaction with peers.	I ask my fellow students for information, explanations, or tips on the content or design of the study task	Organization
	I use the social pressure from my fellow students to engage in studying.	Initiation
	I use feedback from my fellow students to check if I am on the right track.	Task monitoring
	Right before an exam starts, I quickly review the material with one or more classmates to refresh my memory.	Working memory
	I seek support from others to manage my stress.	Emotion regulation
Planning refers to scheduling appointments, deadlines, or the steps needed to complete a task on time.	I plan out what I need to do and when.	Planning
	I stick to the schedule.	Planning
	I make a rough plan where I outline what I am loosely planning to do	Planning
	I have developed routines for myself.	Planning
	I agree with myself in advance on the maximum amount of time I will work on a task.	Planning
	I give myself a deadline for my study task, which forces me to get to work.	Task monitoring
	I use a calendar (digital or paper).	Planning
	I incorporate a study task's requirements, deadlines, and assessment criteria into my planning.	Planning
	I keep a tight schedule.	Planning
	I list the most important tasks or topics and start working on them.	Planning
Problem-solving involves looking for solutions to a problem and implementing the perceived best one.	If I encounter a problem, I look for solutions by myself or discuss it with others.	Flexibility
	If I cannot figure out a problem, I set it aside for a while and return to it later.	Flexibility
	If I do not know how to tackle a problem, I make a step-by-step plan and follow it.	Organization

How Do Students Manage Challenging Study Tasks? - A Thematic Analysis of Higher Education Students' (Non-)Strategic Study-Related Behaviors

Theme	Statement (non-)strategic behavior	Supporting the Executive Function
	I try to solve a problem through trial and error.	Task monitoring
Procrastinating or avoiding refers to delaying or increasing the pressure to start a task or to avoid facing it.	I stop working on a study task if I cannot progress.	Task monitoring
	I start my study task when the deadline is so close that I have no choice but to start it.	Initiation
Self-motivation involves actively or passively finding reasons or feeling the drive to tackle a study task.	I switch between fun and boring study tasks.	Flexibility
	I assess how much effort each study task needs and plan my schedule based on that.	Planning
	I work during the times of the day when I know my energy is higher.	Planning
	I motivate myself to start by reminding myself that it helps me avoid unpleasant things.	Initiation
	During a class, I only pay attention when the topics are important or interesting.	Working memory
Self-reflection refers to thinking about and analyzing one's thoughts, feelings, behaviors, and experiences to gain self-awareness and personal growth.	I reflect on how I handled study tasks in the past to learn from my mistakes.	Task monitoring
Starting and persevering refer to beginning a task and finishing it.	I use tools, like reminders, to help me remember to get to work.	Initiation
	I start a study task without overthinking it.	Initiation
	I study for as long as possible and see how far I get.	Working memory
	I start with a simple or fun task.	Initiation
	I tackle the most challenging task first.	Initiation
	I make sure help is available when working on a study task so I can continue if I have a question.	Flexibility
	I focus on the things that interest me.	Working memory
	When the deadline is near, I feel the pressure and work really hard for a while.	Initiation
Top-down learning refers to starting with an overview or general understanding and	I listen to the entire explanation before I start taking notes.	Working memory
	First, I write down what is said and then figure out what it means later.	Organization
	I attend a lecture before I study the material.	Organization

Theme	Statement (non-)strategic behavior	Supporting the Executive Function
progressively focusing on finer details.	I skim through the study material first and then study it in depth.	Organization
Using examples and feedback refers to applying specific instances or case studies to understand concepts better and incorporating feedback from others to improve one's knowledge and skills.	I use other people's examples, like an existing student summary.	Organization
	I learn in various ways, like through different examples.	Flexibility
Using learning resources to read or watch one or more sources of information to acquire new knowledge or skills.	I use the lecture slides.	Organization
	I use Google or YouTube to understand the material better.	Flexibility
	I prefer to stick to one type of information source when working on a study task. For instance, I prefer studying PowerPoint presentations instead of course manuals or books.	Organization
Visualizing refers to thinking about what to learn and creating meaningful mental images of the study material.	I visualize in my mind what I need to do or how the subject matter is structured.	Working memory

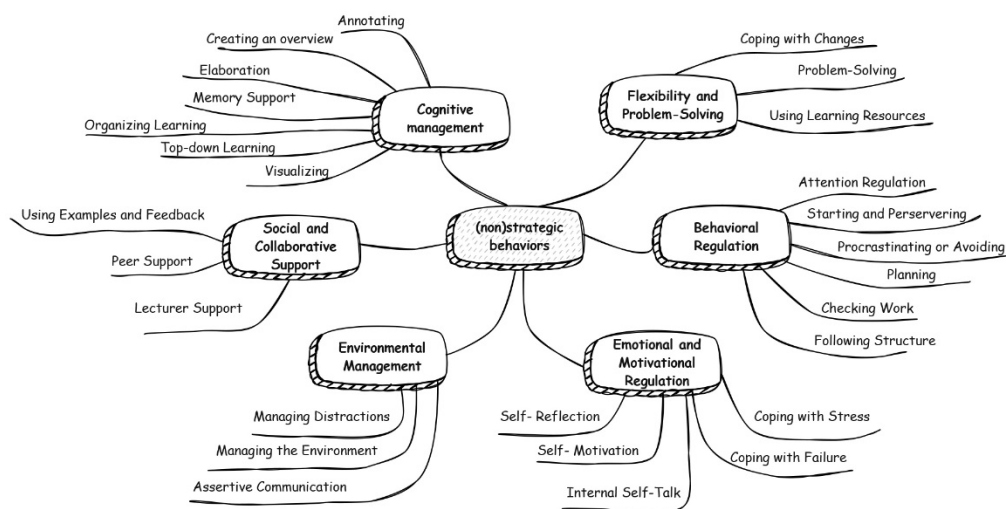
Regarding RQ 1, students' (non-)strategic behaviors, the iterative process led to the interpretation of 89 codes as (non-)strategic behaviors, which were then categorized under 27 themes. Each theme includes at least one (non-)strategic behavior described as a statement. For instance, the theme '*Following structure*' encompasses students' behaviors of adhering to a provided structure, such as '*I do the assigned homework.*'

The 27 identified themes were grouped into six overarching clusters in an additional analysis to provide a more transparent overview and better understand the relationships between themes (see Figure 1). These clusters represent at least a few key processes through which students manage challenging study tasks. The following clusters were identified:

1. *Cognitive Management*: Themes focused on understanding, organizing, and processing information, including annotating, creating an overview, and memory support.
2. *Flexibility and Problem-Solving*: Themes emphasizing adaptability and finding solutions, such as coping with changes, problem-solving, and using learning resources.
3. *Behavioral Regulation*: Themes related to starting, sustaining, and completing tasks, such as attention regulation, planning, and following structure.

4. *Emotional and Motivational Regulation*: Themes supporting emotions and motivation during studying, such as coping with stress, self-motivation, and self-reflection.
5. *Environmental Management*: Themes addressing creating a productive study environment, such as managing distractions and assertive communication.
6. *Social and Collaborative Support*: Themes focused on leveraging social interactions, including peer support and seeking feedback from lecturers.

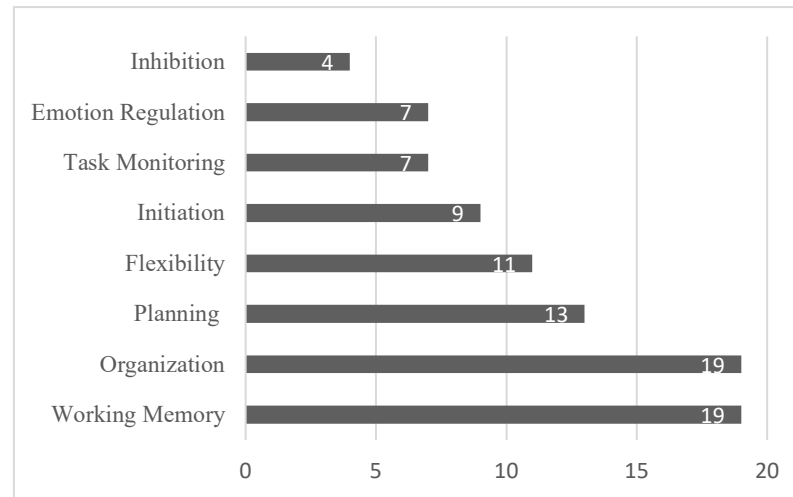
Figure 1.
An overview of the clusters of related themes.



We did not distinguish between strategic and non-strategic behaviors because the distinction between non-strategic and strategic is not always straightforward. However, we observed that students sometimes mentioned *intentionally* using (non-)strategic behaviors, while others mentioned acting *unintentionally*. For example, one student might turn on music without thinking about it. Controversely, another student might play music deliberately, understanding why it works for them, showing more strategic behavior as shown in this quotation: “White noise is also very much conditioned in my head by now to focus.... so as soon as [...] I put white noise on Spotify I do get a focus”. In this case, the student understands a working mechanism (i.e., conditioning), demonstrating cognitive strategy knowledge. Furthermore, we noticed that students mentioned using multiple (non-) strategic behaviors when facing challenges, indicating that students use various (non-) strategic behaviors simultaneously instead of applying a single strategy.

The study's results regarding RQ2, involving (non-)strategic behaviors supporting EF, are illustrated in the last two columns of Table 1. These columns contain the found (non-) strategic behaviors followed by the EF that is predominantly supported by that specific (non-)strategic behavior. For a detailed overview of the (non-)strategic behaviors, executive functions, themes, and quotations, see Supplementary 2; please refer to the link: <https://doi.org/10.17026/SS/XWJRCC>.

Figure 2.
Frequency of (non-)strategic behaviors assigned to specific executive functions.



The distribution of (non-)strategic behaviors across different EFs was uneven; see Figure 2. For instance, self-monitoring had no attributed (non-)strategic behaviors, and EF orderliness had only one (*'I tidy my workspace, including my desk and computer folders, whenever I engage in a study task'*). In contrast, EF organization and EF working memory had nineteen assigned (non-)strategic behaviors. The remaining EFs included four to nineteen (non-)strategic behaviors. Ultimately, we excluded EF orderliness and EF self-monitoring. The most typical behavior assigned to EF orderliness, namely *'tidying up the workspace,'* can also be seen as organizing the workspace. The reason why students did not mention behaviors supporting self-monitoring is unclear. Self-monitoring involves checking, monitoring, and directing one's behavior, especially concerning others. We suspect we did not adequately inquire about this EF during the interviews.

For each EF, (non-)strategic behaviors can be found with similar actions. This implies that students often engage in similar actions to support different EFs, even though the specific goals may vary. For instance, to support their EF inhibition (i.e., the ability to resist distractions), students take steps to eliminate distractions from their environment (*'I make sure there are no external distractions around me'*). At the same time, to support their EF organization, students engage in similar actions but with a different focus; for instance, they aim to organize their study materials (*'I tidy my work area before starting a task, such as organizing my desk or computer folders'*).

6. FUTURE RESEARCH DIRECTIONS

This study underscores the value of qualitative research in capturing the nuanced (non-) strategic behaviors students use to support EFs. Future qualitative research could explore how students perceive the link between these behaviors and academic success, using longitudinal interviews or reflective journaling to trace their evolution.

Additionally, future research could replicate our qualitative study among diverse groups of students in different contexts to further explore the potential types of (non-)strategic behaviors. Also, future qualitative research could inform the design of more personalized educational approaches based on these insights, which could be tested through intervention studies. Additionally, quantitative methodologies could be employed in future research to determine students' preferences and frequency of use for the (non-)strategic behaviors. Lastly, students who participated in the interviews reported that discussing these themes was unexpectedly informative and valuable for enhancing their own metacognitive awareness. Therefore, the selected data collection approach demonstrates practical applicability and merit.

7. DISCUSSION

This study focused on two main research questions: What (non-)strategic behaviors do students exhibit during their studies, and which EFs do these behaviors mainly support?

In response to the first research question, the study unveiled various themes containing both strategic and non-strategic behaviors students employ in learning and studying. Whether a behavior's nature is more strategic or not (e.g., a habit or routine) depends on a student's adaptability in applying the behavior in a particular context and at a specific time. This corresponds with the strategy literature, which defines effective strategy deployment as requiring three types of knowledge: declarative knowledge (understanding "what" to do and "why"), procedural knowledge (understanding "how"), and conditional knowledge (understanding "when") (Van Meter & Campbell, 2020).

The themes and associated behaviors are consistent with theories about how people generally deal with problems, stressors, and other challenges in life, such as assimilation and accommodation (Hanfstingl, Arzenšek, Apschner, & Göllly, 2021). It is noticeable that the themes and (non-)strategic behaviors range from being more internally focused to more externally focused, which fits with human adaptability by changing oneself ('accommodation') or the environment ('assimilation') (Hanfstingl et al., 2021). More internally focused themes included attention regulation, coping with emotions and stress, or asking oneself in-depth questions. Additionally, externally focused themes include interaction with others and resources involving assertive communication, seeking peer support, or setting up an optimal workspace.

The clustering of themes into six categories highlights the multidimensional nature of (non-)strategic behaviors, showing how cognitive, behavioral, emotional, and social strategies are interconnected. The findings underscore the interplay of cognitive, emotional, and environmental factors in learning and studying, resonating with self-regulated learning theories (e.g., Zimmerman, 2015). Self-regulated learning involves the deliberate use of strategies within the learning context. Examples from the study, such as structuring learning material, asking oneself in-depth questions, or repeating information, demonstrate how students exhibit behaviors characteristic of self-regulated learning. Furthermore, students frequently use these behaviors in clusters across categories and themes, adding another layer of complexity to their behaviors. For instance, they combine methods such as organizing their workspace, asking themselves reflective questions, working near peers, and using caffeine.

The second research question delves into EFs' perspectives on (non-)strategic behaviors. EFs do not operate in isolation but interact with other EFs (Miyake et al., 2000). However, in this study, we decided to assign individual (non-)strategic behaviors only to the EF that it predominantly supported. This approach reflects the limited literature on EF strategies in education, which similarly categorizes strategies and recommendations by

individual EFs. This is primarily for practical reasons, as it allows for targeted interventions in education at the level of a specific EF that a student is likely struggling with.

The identified (non-)strategic behaviors support EF in various ways. Some (non-)strategic behaviors are preventive, allowing an EF to remain 'inactive,' while others assist in deploying a specific EF by reducing its cognitive load. For instance, putting away a mobile phone prevents a student from needing to use their inhibitory control to resist distractions. Conversely, playing music to enhance concentration supports the working memory that is active at that moment.

The primary aim of existing literature is to translate theory into practical tools for education. One relevant classification of research-based EF strategies, applicable in both primary and secondary education, originates from the work of Meltzer, Reddy, and Sayer (2014). This classification focuses on EFs influencing academic performance and provides tips and tools. Our study's contribution lies in its comprehensive categorization of non-strategic and strategic behaviors in higher education students, which is not fully addressed in the existing literature. Understanding which behaviors support specific EFs can assist students in identifying which (non-)strategic behaviors aid specific EFs, such as addressing their weak EF.

Another strength of this research, and qualitative research in general, is the rich information that can lead to a deeper understanding of complex human experiences in practice. In our study, we aimed to gather rich data through in-depth interviews by harnessing five researchers' diverse creativity and expertise throughout the various stages of theme development (Vaismoradi, Jones, Turunen, & Snelgrove, 2016). During calibration sessions, (non-)strategic behaviors and themes were discussed, and arguments were presented for the choices.

7.1. Limitations

A strength of this research is our pursuit of information power, as Malterud et al. (2015) suggested. We met four dimensions, justifying our relatively small sample size. However, our study's limitation lies in dimension five, as our chosen analysis strategy requires more cross-case analyses. Researchers compare and contrast multiple cases in cross-case analysis to identify common patterns and differences, which often necessitates a larger sample size to ensure comprehensive coverage of variations. However, the sample size remains a subjective decision of the researchers and depends on their experience (Malterud et al., 2015).

7.2. Educational Implications

Identifying (non-)strategic behaviors holds relevant implications for educators and students. Educators engaged in teaching and student guidance can leverage insights from this study to provide more personalized instruction and coaching. By incorporating findings on student (non-)strategic behaviors into explicit lessons or mentoring sessions, educators can explore the what, how, when, and why of (non-)strategic behaviors, encouraging students to reflect on their usage and identify areas for improvement. For example, the results of this study will be used to develop a mentoring program for first-year students in our Applied Psychology program.

This research offers insights into (non-)strategic behaviors like procrastination or distraction followed by a need to refocus, which can inform the design of learning environments. For instance, including formative and summative assessments with shorter deadlines and supportive prompts in instructional materials can enhance the effectiveness of adaptive learning environments.

8. CONCLUSION

The study reveals that higher education students employ various (non-)strategic behaviors to manage complex study tasks, reflecting the dynamic nature of students' EFs. These behaviors, categorized into 27 themes and six overarching categories, demonstrate that students use deliberate strategies and routine actions to manage their tasks.

The findings could serve as starting points for personalized educational interventions focusing on these diverse behaviors to enhance students' learning and studying experiences. Additionally, the study highlights the need for further research to explore these behaviors' effectiveness and better understand the role of EFs in higher education learning processes.

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Chapter # 35

THE CHALLENGES OF LEARNING TASKS FROM THE PERSPECTIVE OF CHILDREN FROM MARGINALISED ROMA COMMUNITIES

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ABSTRACT

Slovakia is a country of permanent or temporary residence for many nations and ethnic groups, which oftentimes do not have the possibility to receive education in their own language. One of the most controversial linguistic minorities on this front are children from the Roma community, which are commonly marginalised due to different living conditions as well as socio-economic standards. Both these factors highly contribute to segregation of Roma children from the Slovak majority and negatively affect their cultural experience. When entering the formal education system, Roma children do not possess the same linguistic competence of Slovak language as pupils from the major population. In this paper, the authors analysed the textbooks in Slovak: commonly used in the first two grades of elementary schools and attempted to identify the most frequent words, phrases and sentences that children from the Roma community usually encounter in written form, while being educated. By doing so, the authors would like to increase their potential comprehensibility for pupils from marginalised Roma communities. The findings of this research provide a basis for the development of an effective language programme for the second language acquisition of Slovak and urges the Slovak school system to develop a comprehensive national strategy, which would provide adequate language support for children from linguistic minorities.

Keywords: second language acquisition, elementary school education, cultural reproduction theory, inclusive education, learning tasks.

1. INTRODUCTION

Slovakia is one of the smaller countries in the Central European region in terms of population, land area as well as economic performance. The population of Slovakia (circa 5.5 million inhabitants) lives on approximately 49 thousand km² of land area. Due to its position within the Central European region and its historical border changes, Slovakia has experienced an extensive migration throughout history, which brought in a lot of inhabitants of various national as well as ethnic groups and made it a multicultural country. According to the latest Slovak Population and Housing Census, the current population of Slovakia is made up of 29 different nationalities as well as 26 language groups, which primarily differentiate in the usage of their mother tongue. The dominant language of the local school system is Slovak (Statistical Office of the Slovak Republic, 2021). In the school year 2023/24, 93 % of primary school students were educated in the Slovak language (CVTI, 2024). Children within Hungarian, German, Ukrainian, and Ruthenian minorities should have the opportunity to receive education in their mother tongues. The greatest controversy seems to be the unresolved issue of Roma children's education, who still do not have the opportunity to be educated in their native Romani language.

Based on the current field research almost 50% of Roma communities in Slovakia use Romani language on daily basis, while Slovak is being used only in 35% of them (Ravász, Kovács, & Markovič, 2020). As the majority of pupils from the Roma community do not encounter or comprehend enough Slovak before they enter the elementary school, their cognitive development is oftentimes insufficient. This furthermore makes their adaptation to Slovak public schools significantly inhibited. The reasons for this are discussed in greater detail in the subsequent section of this chapter.

2. BACKGROUND

2.1. Equality of Educational Opportunities from the Perspective of Roma Children

There are qualified estimates of 417,000 Roma living in Slovakia at the time of writing, representing 7.6% of the total population. They are not a homogeneous group, even in terms of their social situation. The fact is that half of them experience some type of spatial segregation - 14% live in isolation outside villages, in so-called settlements. Another 36% live in gated communities on the periphery of villages (Ravász et al., 2020). Spatial segregation leads to school segregation at all levels of the education system. Several studies point to the problem of the existence of segregated ethnically homogeneous schools or classes within ethnically mixed schools (Friedman, Surdu, Gallová-Kriglerová, Kubánová & Slosiarik, 2009; Hapalová, 2019; Hapalová & Hvozdovič, 2013; Gallová-Kriglerová, 2015; Lajčáková, Gallová-Kriglerová, Kadlečiková, Balážová & Chudžiková, 2017; Rafael, 2011; and others). Segregation also seems to be a consequence of some public policies aimed at improving the educational opportunities of Roma pupils. Assigning children to homogenous classes based on ethnicity – Roma classes to close the gap in their school readiness or improve their academic performance ultimately results in their long-term isolation from other peers. Being educated in an ethnically homogeneous environment offers them almost no advantage, even in terms of the language of instruction. In these so-called Roma classes, the language of instruction is still Slovak. According to some studies, the use of Romani is seen as undesirable even during breaks (Kusá, 2016).

The issue of education of Roma children from socially excluded backgrounds is very complex. It cannot be satisfactorily analysed within the scope of this paper. However, to gain a deeper understanding of this study, it is necessary to point out several facts:

1. The educational level of the Roma population is generally low. The highest incidence of people with incomplete education or only primary education is in the regions of Slovakia where the Roma population lives (Statistical Office of the Slovak Republic, 2024).
2. Generations of Roma children from marginalised communities (hereafter referred to as MRC) have not been adequately included in preschool education programmes. Although the overall enrolment rate for children aged 3-5 years was 75% in the 2018/19 school year, it was only 32% in the MRC setting (Hellebrandt et al., 2020). Several barriers contribute to the low attendance of these children (Vančíková, 2019a), which have not been fully eliminated even after the adoption of the law on compulsory pre-primary education for all 5-year-olds in 2021.
3. A large group of Roma children from the MRC do not meet the school readiness criteria at the schooling threshold and as a result, they repeat a grade in the first years of schooling (Vančíková, 2019b).

4. School failure accompanies them in the following years of schooling. A significant group of these pupils do not continue their studies in secondary school. The proportion of pupils who complete compulsory schooling and do not continue their education is significantly higher in socially disadvantaged groups than in the rest of the population (Hellebrandt et al., 2020).
5. It's not common for people from these communities to achieve higher education. According to data in 2015 only 0.14% of all Roma living in rural areas have achieved higher than secondary education (Mušíinka & Matlovičová, 2015).

2.2. Education of Roma Children from the Perspective of Respecting their Linguistic Rights

Although the Education Act No.245/2008 Coll. (§12) states that different nationalities have the right to education and education in their language, a large group of children in Slovakia are educated in a language other than their mother tongue or are in the situation of acquiring another language and learning in it at the same time. In terms of the application of linguistic human rights, sub dimensional, so-called 'sink or swim' programmes are applied to children of several minorities in Slovakia (cf. Skutnabb-Kangas, 2000). Pupils entering the school from a foreign language background are forced to acquire Slovak as the language of the school, representing the language of the majority society. Children in the MRC mostly encounter this form of language only when watching television or in games run by older, school attending children (Kubánik, 2015). For them, entering school is not only an encounter with a new linguistic reality but also with a new approach to language learning. In their home environment, language acquisition occurred in natural communicative situations that they experienced or were part of. At pre-school age, they acquired Romani, the local dialect of Slovak and other languages spoken in their primary environment. Thus, they naturally became bilingual or plurilingual, without formally being taught vocabulary, corrected, etc. The school approaches language learning in a completely different way. The basis is targeted language education through the learning of individual concepts and grammatical rules, which contradict natural and unguided acquisition (Hajská, 2015). Thus, these learners must acquire not only a new language, but also a new form of learning. The school expects every pupil entering its grounds to know the rules of behaviour and communication or to understand the language they are being taught. It does not respect the diversity that is natural, as each pupil comes from a different background. It demands uniformity and thus creates barriers that pupils from poor backgrounds find difficult to overcome.

Their families' economic situation affects its living conditions, far below majority standards. Their homes often have no access to electricity or drinking water, are inadequate in terms of space, and have a high number of household members (FRA, 2016). A child born in such an environment has compromised living conditions from the outset. 'More than a third of Roma do not receive adequate health care from birth, and this has an impact on their overall health' (Chovan et al, 2022). Poor childhood health has a significant impact on the willingness to meet the demands of schools, which overlook differences in socioeconomic background of their pupils. Family history also has a significant impact on early literacy development and a wide range of social, linguistic, cognitive, and noncognitive experiences associated with reading that contribute to reading comprehension and are important for future reading success (Zápotočná & Urban, 2020). These factors shift the imaginary starting line of MRC pupils in the wrong direction. The excessive burden that accompanies them from the moment they enter primary school is paid no attention to in the assessment or adaptation of the school curriculum. The school demands

the same performance from them as from children from families with a much better socioeconomic background. Thus, from an early age, without a helping hand, children of the MRC face frustration and failure.

2.3. Linguistic Competence Capital of Children from Excluded Localities

The main thesis of the Theory of Cultural Reproduction by the French sociologist Pierre Bourdieu is that the school, as a social institution, should contribute to the levelling of social inequalities (Bourdieu, 1986). However, the Slovak schools do the opposite, widening the gap and applying the Matthew effect: 'For whoever has will be given more, and they will have an abundance. Whoever does not have, even what they have will be taken from them (Matthew 25:29).' They privilege those who have acquired skills, tastes, or ways of spending time - the cultural capital of the middle and upper social classes. It presents the values of these parts of society as universally perfect and demands them from everyone wanting to participate in education (Feinstein, 2003; Prokop, 2005; Van de Werfhorst & Hofstede; 2007). Acquisition of the cultural capital of the majority is impossible for children from segregated Roma settlements because their contact with the majority happens rarely, if at all. Thus, they continue to live in generational poverty, with low educational levels and ingrained patterns of behaviour that are undesirable and judged as insufficient in the school environment.

This thesis is supported by Andersen and Jaeger (2015, p. 185): 'Children who enter school with the necessary cultural capital are more successful in achieving educational outcomes. They are perceived by teachers as more talented than they are (leading to better subjective ratings from teachers and better grades) and have a more welcoming learning environment (as the teachers pay more attention to them).' The so-called Golem effect, often associated with teachers' low expectations of pupils from low socioeconomic backgrounds, has an impact on pupils' motivation to learn, which is reflected in their school adjustment and educational outcomes. Without a deeper understanding of the sociocultural background of MRC pupils, it is difficult for the majority teachers to empathise with the reality from which they come and to understand the obstacles they must overcome in the school environment. Linguistic capital is an important part of cultural capital. In both spoken and written form, the school speaks to all pupils in the same language, which may not be comprehensible to them. The British sociologist Basil Bernstein in his sociolinguistic theory demonstrated that the social conditions of life create at least two forms of language use: a limited language code typical of lower social classes and a developed language code characteristic of middle and upper social classes (Prokop, 2005). The language of the school speaks to children with a developed linguistic code. Children bring with them different cultural and linguistic capital from their home environment. The latter also influences parents' contact with teachers. Parents in lower social classes do not feel competent enough to communicate with teachers. They are uncomfortable communicating with teachers and believe that school is separate from home. In their perception, education is the responsibility of teachers, so they avoid contact with the school (Dumais, 2006). Their limited cultural experience and language code affect their competence capital, which reflects their competence in social communication and orientation to socially relevant topics (Vančíková, 2011). Therefore, schools should consider the cultural and linguistic background of each child and adjust their approach to education accordingly.

2.4. Research Problem and Objective of the Study

The previous section highlights that the education system in the Slovak Republic does not cater for all children. Children from poverty-stricken foreign language backgrounds face issues such as poor educational performance and early school abandonment, raising concerns about the school conditions. Therefore, we have decided to investigate the language teaching tasks in textbooks for the first and second years of primary education. Our objective is to identify the most used words and sentences and evaluate their potential clarity for children living in MRC.

3. METHODS

The research set consisted of textbooks for the first and second years of primary education which have the so-called clause of the Ministry of Education, meaning they are the state-supported teaching resources used by many primary schools. The subject of the analysis was 6 textbooks and workbooks for the 1st grade, in which 1735 teaching instructions were recorded. For Grade 2, we analysed 7 textbooks and workbooks in which we identified 4231 instructions. The initial transcript created a corpus with a total of 5966 teaching instructions.

The analysis was carried out in cooperation with the Ľudovít Štúr Institute of Linguistics of the Slovak Academy of Sciences. The analysis consisted of several steps:

1. Morphological analysis:
Words have been classified into 4 categories: nouns, verbs, adjectives, and adverbs.
2. Frequency analysis:
In each category, frequency lists have been created to judge the frequency of occurrence of individual words in the learning resources.
3. Comparative analysis 1:
Identification of vocabulary specifics when comparing grades (comparison of 1st- and 2nd-grade textbooks) and specifics when comparing vocabulary within subjects (Mathematics, Slovak language, Natural Science). The result of the analysis is the unique vocabulary, which is found only in one set (for example, only in mathematics textbooks, etc.)
4. Comparative analysis 2:
Identification of common vocabulary for monitored categories (e.g. what words can be found in all first-grade textbooks, etc.)
5. Comparative analysis 3:
Identification of the most frequently used sentences in all subjects (Mathematics, Slovak language, Natural Science).

The analysis of textbook vocabulary was the starting point for the next step, identifying challenging words and sentences. In the context of our research goal, a challenging word/ sentence is any word/sentence that is potentially outside the scope of the cultural or competence capital of a child living in conditions of social exclusion. The starting point for identifying such words was a set of the most frequent words in four categories: 1) verbs, 2) nouns, 3) adjectives, and 4) adverbs. The condition for including a word in the sample set was its occurrence in textbooks of all subjects (common vocabulary). A set of the most frequently used sentences was used in the recorded teaching instructions to identify challenging sentences.

4. RESULTS

As can be seen in Table 1, we identified several challenging words in each type of words. There were 13 words in the verbs category, 14 words in the nouns category, 6 words in the adjectives category, and 3 words in the adverbs group.

Table 1.
Frequent Common Vocabulary in Mathematics, Slovak Language, and Natural Science
Primary School Books with Identified Challenge Words.

Word Categories	Vocabulary
Verbs	byť (be), doplniť (fill in), mať (have), vyfarbiť (colour) , zapísať (write down) , pozorovať (observe), zistiť (find out) , vyznačiť (mark) , nakresliť (draw) , vytvoriť (create), nájsť (find), vymyslieť (invent), dokresliť (complete the drawing) , pomôcť (help), napísať (write to) , môcť (able), prečítať (read) , zdôvodniť (rationale) , povedať (say), pokúsiť (try) , porozprávať (talk), pomenovať (name) , dopísať (complete) , vypísať (write out) , urobiť (to do)
Nouns	číslo (number), počet (count) , priklad (problem) , úloha (task) , bod (point), výsledok (result) , pastelka (crayon) , vzor (pattern), tabuľka (chart) , znak (sign), kocka (cube) , farba (color), dvojica (couple), rad (row) , veta (sentence), spolužiak (classmate), rastlina (plant) , živočích (animal) , informácia (information) , človek (human), plôška (spot) , voda (water), slovo (word), obrázok (picture), písmeno (letter) , príbeh (story), názov (title) , časť (part), meno (name), odpoveď (answer), otázka (question)
Adjectives	veľký (big), rovnaký (same), správny (correct), červený (red), modrý (blue), zelený (green), slovný (verbal) , ďalší (next), ľubovoľný (random) , žltý (yellow), rôzny (various) , pravdivý (true), prázdny (empty), jednotlivý (single) , spoločný (common), nový (new), starý (old), potrebný (necessary), podobný (similar) , vhodný (suitable)
Adverbs	spolu (together), dlho (long time), doma (at home), ešte (yet), najskôr (first), podobne (similarly) , postupne (gradually) , potom (after), pozorne (carefully) , rovnako (same), spoločne (in common), správne (correctly), teraz (now), treba (be necessary), už (already)
Note: Difficult words are highlighted with a bolt.	

We identified 11 challenging sentences, which can be seen in Table 2. The selection was made from the top 30 most frequent sentences used in the textbooks.

Table 2.
Frequently used sentences in primary school mathematics, Slovak language, and natural science textbooks with identified challenging phrases.

Sentences
Vypočítaj (Compute). Rozprávaj (Talk). Prečítaj (Read) . Kresli (Draw). Pozoruj (Observe). Rozmýšľaj (Think about). Pomenuj obrázok (Name the picture) . Dopln (Add). Prečítaj vety (Read the sentences). Dopln vety (Complete the sentences) . Pomôž si informáciami zo Zapisníka cestovateľov (Help yourself with information from the Travellers' Notebook). Porovnaj (Compare) . Prečítaj slová (Read the words). Slová napíš (Write the words). Vyrieš slovnú úlohu (Solve the word problem) . Svoje rozhodnutie zdôvodni (Give reasons for its decision) . Pozoruj obrázok (Observe the picture). Píš (Write). Zapíš počet (Write down the number) . Pomôž si encyklopédiou alebo internetom (Help yourself to an encyclopaedia or the internet) . Urob vyhodnotenie (Do the evaluation) . Vetu prečítaj (Read the sentence). Vety napíš (Write the sentences). Slová použi vo vetách (Use the words in sentences). Prečítaj báseň (Read a poem). Počítaj (Count). Pozoruj obrázky (Watch the pictures). Dopln číselný rad. (Complete the number series) . Dopln chýbajúce čísla (Fill in the missing numbers). Bádaj (Do research) .
Note: Difficult phrases are highlighted with a bolt.

Words and sentences were identified based on a study of the social and linguistic background of children with MRC living in the Slovak Republic. The words and sentences in the tables are also given in their original form because the English translation does not capture their essence in the Slovak language.

5. DISCUSSION

Based on the results of the content analysis of textbooks from the first and second year of school education, we can establish the assumption that there are teaching instructions with the difficult words and sentences, posing a problem for Roma children who use Romani in the home environment and at the same time live in conditions of poverty and social exclusion. As Kyuchukov, de Villiers, and Tabori (2017, p. 218) mentioned in their study: 'Although children have good knowledge of their mother tongue, this skill is not seen as an asset when it comes to school placement in several European countries.' The Slovak education system is one such example. As evidenced by the findings of Programme for International Student Assessment (PISA), it is one of the systems that demonstrates the most significant impact of socio-economic background on learning outcomes in international testing (Miklovičová & Galádová, 2023). The linguistic capital of these pupils is comparatively limited in comparison to their classmates from mainstream society (thanks to the language of the school), which constitutes a significant barrier to their success at school. At this point, we can say that simultaneous study of the language of instruction and a different curriculum in a classroom with native speakers can result in stress and loss of self-confidence for pupils with different mother tongues (Piller, 2016). Pupils may have difficulty communicating with people around them, which can result in their exclusion from the community. This can lead to feelings of loneliness and isolation.

Alternatively, students from less privileged socioeconomic backgrounds who experience academic success at an early age may increasingly regard education in a positive light. They may come to view the accumulation of language and cultural capital via schooling as a means of social mobility, overcoming the impediments to opportunity associated with their class position. The positive effects of academic success and increased cultural capital (including the language) on students' aspirations and orientation have been demonstrated by Edgerton and Roberts (2014).

6. FUTURE RESEARCH DIRECTION

The findings from this phase of research will be validated in the subsequent phase of the investigation through the administration of interviews with pupils at the MRC. The objective is to ascertain how they comprehend challenging vocabulary and sentences and to identify any erroneous assumption. The findings of this research will provide a foundation for advocating for the establishment of support mechanisms for children whose linguistic rights are infringed upon and subjected to a phenomenon commonly referred to as 'subordination'. It is argued that the school readiness of these children and the likelihood of their academic failure can be enhanced by the implementation of the effective language acquisition programmes in Slovak. Concurrently, educators must possess the requisite competencies to effectively engage with this cohort of children. This necessitates a nuanced understanding of their life experiences and an appreciation for the intrinsic capabilities they bring to the learning environment.

7. CONCLUSION

It turns out that Bourdieu's theory of cultural reproduction and his critique of the school are still valid. Despite deepening social differences, the school continues to use a language that is more likely to be understood by children whose cultural capital is compatible with that of the school. In a country with a large group of socially disadvantaged children, it is, therefore, necessary to present research arguments that can not only initiate dialogue on the subject, but also develop comprehensive methodological support for teachers who work with this group of children.

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KEY TERMS & DEFINITIONS

Marginalized Roma communities – communities of people of Roma ethnicity who, due to objective circumstances, find themselves in a disadvantaged situation that prevents them from fully accessing cultural resources.

Linguistic Rights refer to the human and civil rights that guarantee individuals and groups the freedom to select the language or languages they wish to use for communication, whether in private or public settings. In the context of our study, these rights pertain to the right of Roma children to use their mother tongue in education.

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Chapter # 36

UNDERSTANDING THE LEARNING SPACE: A BIBLIOMETRIC ANALYSIS ON BLENDED LEARNING IN HIGHER EDUCATION

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ABSTRACT

Learning in higher education was predominantly the traditional face-to-face type of learning. Blended learning has been adopted as the relevant approach to teaching and learning, based on the lesson learned during the COVID-19 period. The concept “learning space” refers to a full range of spaces in which learning occurs, from real to virtual learning, and from the classroom to chat rooms. Blended learning necessitates an understanding of the learning space and design, pedagogy and curriculum, and their relation to the learning space. The learning space is critical for the realisation of learning outcomes. Online learning cannot replicate everything of value in the face-to-face experience of learning. The reflection on the blended learning approach is guided by the conceptualisation of learning as acquisition, learning as participation, and learning as knowledge creation. This study reflects on trends in blended learning (between 2013 and 2024), as aided by an extensive literature review. A qualitative methodology was employed, and data was analysed using the bibliometric analysis. This chapter discusses the effects of blended learning on students. This study is significant as it helps improve lecturers’ implementation of blended learning, which would translate into developing essential online and face-to-face learning pedagogy, as institutions of higher learning globally have adopted blended learning.

Keywords: bibliometric analysis, blended learning, learning space, higher education.

1. INTRODUCTION

Technological advancement has largely contributed to the introduction and implementation of blended learning across the globe. Harper, McCormick, and Marron (2024) have reported significant changes in higher education institutions across the globe, especially on the academic landscape, due to the COVID-19 pandemic. Accordingly, Harper et al. (2024) have highlighted that the most significant change in this regard, has been the abrupt shift from traditional classroom teaching and learning to online learning, as the lockdown restrictions compelled higher education institutions to shut their campuses.

With a shift from face-to-face learning, remote or online/digital learning became an integral part of tertiary/higher education (He, Edwards, & Schwarte, 2024). Generally, in almost all the countries, this shift was attributed to the COVID-19 pandemic.

The effectiveness of the traditional classroom teaching and blended learning is influenced by several factors. According to Ait Daoud, Namir, and Talbi (2024), the term “blended learning” is used more frequently in today’s education cycles. Accordingly, Ait Daoud et al. (2024) maintain that blended learning is not a new term, many organisations throughout the world have, for many years, implemented and explored blended learning. Similarly, Mohamed (2024) states that blended learning has undergone some notable shift in its application over time.

Furthermore, Chilton, Hanks, and Watson (2023) point out that much has been learned about higher education institutions and how they could best provide blended learning environments, especially during crises like COVID-19, as well as during “normal” times. However, the scholars (Chilton et al., 2023) assert that access to technology, and the ability to use it, are crucial for the success of online/remote learning.

Castro (2019) and Hermita, Alim, Putra, Mahartika, and Sulistiyo (2023) define blended learning as a mode of learning that combines in-person teaching with online learning. These scholars also argue that the aim of designing blended learning is to improve the efficacy of traditional classroom teaching and learning. Ultimately, Mahmood, Sharif, and Aleem (2024) postulate that blended learning is an innovative and more efficient way of learning, as it transcends the boundaries of space and time, and broadens possibilities. Furthermore, blended learning is seen as an emerging and crucial mode that offers additional activities for the reinforcement of learning.

The scholar (Mohamed, 2024) also notes that the role of teachers in blended learning goes beyond being knowledge providers: it extends to advisors, moderators, learning guides, and facilitators. This notion is supported by Du et al. (2022), who postulate that blended learning is a student-centred model, where teachers play a guiding and supporting role of assisting students to use the existing knowledge reserved to learn, comprehend, and internalise new knowledge. According to Mohamed (2024), the shift noted here acknowledges the significance to foster active and engaging learning environments.

This chapter is divided into seven sections. The first section provides background to the concept of blended learning. The second section presents the aims and objectives of the study, while the third section outlines the methodology and data collection strategies. The fourth section presents the results of the data analysis and the overall findings. The last section presents the discussion, limitations of the study, make suggestions for future research, and draws the conclusion.

2. BACKGROUND

Due to the outbreak of the COVID-19 pandemic, teaching and learning activities were shifted to online learning. However, because of the urgency of this ‘transition’, time was not enough to plan and prepare for this change. Hence, some scholars refer to this remote teaching and learning as Emergence Remote Teaching (ERT). Blended learning promotes both face-to face and online teaching and learning. Eventually, this means adopting a new learning space in higher education. Online teaching and learning called for innovation and the creation of relevant learning spaces. This brought different challenges to lecturers or teachers. Different higher education institutions used different Learning Management Systems (LMSs), based on their preferences. Nonetheless, the effective usage of all these in teaching and learning depends on the teacher’s or lecturer’s creativity and willingness to learn to make teaching effective and productive for students’ achievement or benefit. A vast body of literature suggests that the learning space in higher education is under-researched and un-theorised. This bibliometric analysis, therefore, explores trends in blended learning as a unique learning space. In other words, this study describes the most common practices on blended learning in higher education based on the data that was obtained from Scopus and analysed using VOSviewer. Important to note is that, the study also identified the gaps in blended learning, which could be subjects for future research.

2.1. Research Aims and Objectives

The study aimed to answer the main question:

What are the major trends in implementing blended learning in Higher Education?

The main objectives of the study were:

1. to map out the research focus on blended learning in higher education in the last 10 years.; and
2. to identify global trends in scientific research on blended learning in Higher Education.

3. METHODOLOGY AND DATA COLLECTION

A bibliometric analysis was conducted to explore the implementation of blended learning in higher education institutions mainly to identify trends in blended learning. To achieve this, the researcher critically reviewed co-occurring keywords. Data was retrieved from the Scopus database. Scopus is one of the databases that researchers broadly rely on when conducting bibliometric analyses in the academic literature (Farooq, 2023).

The search was restricted to article title, abstract, and keywords, using the Boolean “OR” - “AND”. Therefore, the researcher used the search string “blended learning” AND “higher education institutions” OR “universities”. This search produced 5 062 documents.

The search was refined to focus on the years 2013 to 2024 and included subject such as social sciences and arts and humanities, and the type of document was limited to article, and the language restricted to English only. This final search yielded 1 594 documents. The data retrieved from Scopus was analysed using VOSviewer. According to Di Matteo, Nardi, Grego, and Guidi (2018), VOSviewer is the Visualisation of Similarities software.

4. BIBLIOMETRIC ANALYSIS AND RESULTS

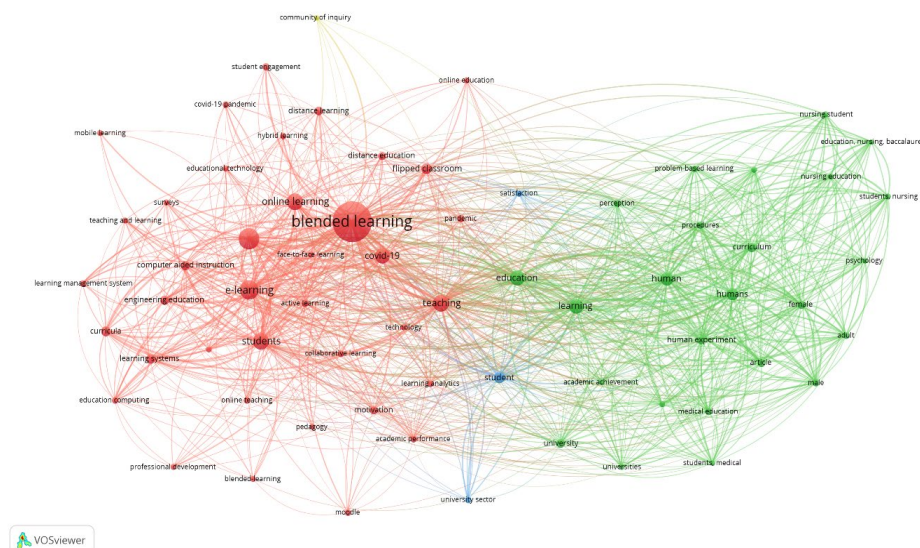
4.1. Keyword Co-Occurrence

The objective was to map out the research focus on blended learning in higher education in the last 10 years. According to Qing, Chun, Ock, Dagestani, and Ma (2022), keyword co-occurrence could explain the research hotspots in the field over a specific time. These keywords would enable the identification of the important themes in blended learning in higher education and observations around the trending concepts in blended learning.

For this study, the minimum number of keyword occurrence was set at 20, this is because blended learning is not a new phenomenon in higher education, as researchers have argued. Of the 4 924 keywords, 67 met the threshold. The list of the co-occurring keywords is presented in the four themes that the researcher has developed and analysed.

Co-occurrence in this study refers to the frequency with which a particular keyword appears with other keywords. The results indicate that blended learning had a strong link of 1 989, and had 945 occurrences. Similarly, teaching as a keyword had a strong link of 1 015, with 161 occurrences. Another important keyword was education, which also had a strong link of 844, with 139 occurrences. The 67 co-occurring keywords are displayed in Figure 1 below.

Figure 1.
Network Visualisation of co-occurring keywords.



4.2. Cluster 1: Blended Learning as a Learning Space

The first cluster consisted of 38 items. However, for this study the researcher had to focus specifically on some keywords to align the study to the main research question. Some of these important keywords are: academic performance, active learning, collaborative learning, flipped classroom, learning analytics, motivation, pedagogy, professional development, and student engagement. The researcher needs to point out that the discussion of the co-occurring keywords was also guided by the emphasis of the literature on blended learning regarding these keywords.

The co-occurring keyword “collaborative learning” emphasises the importance of collaboration during teaching and learning. However, the type of collaboration emphasised is immaterial, this could be student-student collaborations, or student-teacher collaboration. Interestingly, Guo (2024) postulates that the significance of collaborative learning is emphasised, hence, the role of this collaborative learning is considered crucial to knowledge construction.

The appearance of the keyword “COVID-19 pandemic” in the first cluster is/was expected, since most HEIs shifted to online learning, and later, blended learning, following the COVID-19 pandemic. Chilton et al. (2023) have highlighted that the impact of COVID-19 on higher education has acted as a global experiment in remote learning; hence scientific findings must inform the implementation of blended learning in HEIs. On the other hand, Harper et al. (2024) state that the impact of the COVID-19 pandemic contributed to increased mental health challenges, stress and other external factors among students, these might have also influenced academic outcomes during this time.

The appearance of the co-occurring keyword “pedagogy” reveals the importance of the process of teaching and learning, irrespective of the mode of delivery. Hence, Anderson (2020) argues that the term “pedadgogy” does not refer to the mere deployment of the methods and learning techniques. The scholar (Anderson, 2020) further postulates that

effective pedagogy equips students for life through the development of their personal, intellectual and social resources. The scholar is of the view that good pedagogic practice encourages student engagement with highly considered forms of ideas, knowledge, ways of thinking and forms of discourse, and practices relevant to every individual's context.

Another important co-occurring keyword was “flipped classroom”. It is noteworthy that Danker (2015) explains that the flipped classroom enables the redesign of large lectures into active-learning classes, made of small groups. Danker (2015) also highlights that active learning in small groups facilitates student engagement, where they could participate, develop higher-order thinking skills, and receive feedback. Interestingly, Danker (2015) also found that the flipped classroom approach promotes individualised learning. According to the scholar, the flipped classroom fosters an environment that increases the interaction between teachers and students, and enables student engagement through practice and application.

Research on blended learning seems to have covered learning analytics, and outlined the significant role of “learning analytics” in the blended learning mode. Accordingly, Siemens (2013) defines learning analytics as the “collection, analysis, measurement and reporting of data about students and their context, simply for the purposes of comprehending and optimising learning as well as the environment in which it occurs”.

On the other hand, Wang, Wu, Chen, and Li (2017) argue that learning analytics could aid the recommendation of personalised learning resources and the construction of individualised learning models; thus, fostering a more accurate approach to personalised learning. Furthermore, this process promotes self-adaptive learning that caters for the unique needs of each student as it also enhances the entire learning experience and outcomes.

Another trend is student engagement. In this regard, Yang and Ghislandi (2023) maintain that student engagement is a qualified proxy for quality learning and teaching. This is confirmed by Mohamed (2024), who argues that combining face-to-face learning with a blended learning framework has revealed an increase in student engagement as well as collaboration with instructors and peers. Accordingly, Mohamed (2024) argues that blended learning facilitates the creation of an interactive and dynamic learning space, hence, fostering active engagement among students, resulting in enhanced academic achievement.

Wang et al. (2017) sum up the argument made in cluster 1. The scholars argue that education is no longer something that is imposed externally on students, or just forced onto beings, rather it must emanate from students themselves.

4.3. Cluster 2: Academic Achievement and Problem-Based Learning

This cluster contained 25 items. The keyword “academic achievement” occurred in both clusters 1 and 2; although in the first cluster it was captured as “academic performance”. Therefore, the importance of students achievement in blended learning cannot be over-emphasised. As Mahmood et al. (2024) reveal that, numerous studies have recently explored the impact of the incorporation of blended learning on student academic performance. Furthermore, the study conducted by Mahmood et al. (2024) revealed that a blended learning approach, with some targeted effort, enhances students performance. Moreover, the scholars argue that this was influenced by the enabling opportunities that students had been afforded, such as collaboration facilities through online mediums, and better interaction, which contribute to increased learning.

Regarding “curriculum” as one of the significant concepts in teaching and learning, ElSayad (2024) maintains that in a blended learning set up students are presented with a portion of curriculum, using online delivery, which affords them some autonomy over the location, schedule direction, or speed of their learning process. Consequently, students

become more responsible and independent, and are in charge of their remote learning. This means that, in blended learning it is always facilitators or lecturers who have the task of deciding how they will teach the different components of the curriculum. Ultimately, blended learning, according to Guo (2024), is an effective way for instructors to carefully design teaching before the lessons, organise classroom activities during the lesson, and test the effectiveness of learning after the lesson.

Problem-based learning, affords students an opportunity to become active constructors of knowledge. According to Guo (2024), in a blended learning set up the teacher assumes the role of a helper, guide, organiser, and facilitator of meaning construction and, therefore, plays a mediating role during the learning process. The argument around “problem-based learning” also comes to the fore as “problem-based learning” was one of the key co-occurring keywords in cluster 2. Generally, problem-based learning is considered one of the most important elements of high-order thinking, and it develops students’ critical thinking. Students who are engaged in problem-based learning more often display the skills and the ability to make decisions. The appearance of the keyword “problem-based learning” confirms Mahmood et al.’s (2024) assertion, who supported previous studies that a blended learning approach promotes higher-order thinking better than traditional teaching practices.

4.4. Cluster 3: Student Satisfaction

This cluster has three items only, namely “satisfaction”, “student”, and “university sector”. Student satisfaction with the teaching and learning process is critical, since it might contribute to student attitude to learning, which could impact academic achievement. In their study, He et al. (2024) found that teacher support facilitates student course engagement, and consequently, student satisfaction.

Some of the important factors that contribute to student satisfaction in teaching and learning are feedback and academic performance. As Wang et al. (2017) argue, using LMS in blended learning allows for more timely and equitable feedback. The scholars are also of the view that improved feedback mechanism fosters student motivation as they feel acknowledged and more engaged in the learning process.

The study conducted by Chilton et al. (2023) revealed that students appreciate remote learning in other context, but that this should be complementing and should not necessarily supersede face-to-face mode of delivery. Ultimately, Chilton et al. (2023) warn that HEIs and teachers should be dynamic and flexible in their interactions with students and acknowledge that this is not a one-size-fits-all model.

4.5. Cluster 4: Community of Inquiry

“Community of inquiry” was the only co-occurring keyword that was displayed under the last cluster. This study confirms Castro’s (2019) findings, wherein most of the trends that were identified from a pedagogical perspective consisted of models, frameworks, as well as practices at individual and group level; for instance, student-centred approaches, active learning, flipped classrooms, peer collaborative learning, and communities of inquiry. However, most of these trends fall under the second cluster as discussed above.

Progressively, Teane (2024) states that cognitive presence as part of the theory of a community of inquiry refers to the extent to which individuals could construct and confirm meaning through sustained discourse and reflection, this speaks to what is referred as knowledge construction. Accordingly, Castro (2019) notes that the core elements of communities of inquiry under practices at group level include among other things, social, teaching, and cognitive presence. This confirms an assertion by Yang and Ghislandi (2023),

who clarified that the community of inquiry framework argues that teaching presence, cognitive presence, and social presence are necessary for an enriched online learning experience.

Similarly, Pei, Poortman, Schildkamp, and Benes (2024) maintain that good social relationships do not ensure academic success, and note that cognitive presence covers the learning aspect. On the other hand, teaching presence is considered the facilitation, instruction, and direction of students' cognitive and social presence to ensure educationally and personally meaningful learning outcomes. Last, social presence focuses on students' ability to project themselves emotionally and socially for the development of inter-personal relationships in a more trustworthy environment.

5. DISCUSSION

Pei et al. (2024) maintain that for two decades, blended learning has been considered one of the fastest-growing trends in higher education. Part of the victories that we can celebrate in the implementation of blended learning is that it discourages the one-way transmission of knowledge from lecturers to students if thorough planning for this mode of delivery is done in advance. It is noteworthy that blended learning, if implemented correctly, would promote student-centred learning, through problem-solving learning, engagement, collaboration, and active learning, hence also enhancing student motivation and satisfaction with teaching and learning, and academic achievement. Notably, in blended learning students for instance, construct knowledge, based on their experience and as they interact with peers and content. This confirms Mahmood et al.'s (2024) findings that problem solving, engagement, and active learning are pivotal in the blended learning approach, wherein students are interpreting and exploring information, instead of passively receiving it. Hence, Mahomed (2024) has recommended that educational institutions should utilise blended learning to further improve student participation and engagement in learning.

Above all, blended learning presents itself as a different learning space. Moreover, the pedagogy, teaching, and learning unfold in a manner that would ensure that everything is student-centred. As Wang et al. (2017) contend, in a blended learning environment students are responsible for actively constructing and engaging in different cognitive activities. This means that they are actively engaged in discussing, creating, thinking, reflecting, collaborating, and investigating.

It is important to note that “curriculum”, “teaching and learning”, and “perception” as co-occurring keywords also suggest that lecturers should plan to implement a blended learning delivery mode, based on their knowledge of their students' different learning experiences, as blended learning allows for a personalised learning experience. This finding supports the results of a study conducted by Ait Daoud et al. (2024) that suggested that lecturers should consider the different learning styles of their students when designing and delivering blended learning courses.

The introduction of a new learning and teaching mode of delivery suggests the use of various technologies – information and communication technologies (ICTs) in HEIs. The appearance of the co-occurring keyword “professional development” suggests that there is generally, a need for in-service or upskilling, or the re-skilling of professionals in the teaching and learning field. Ayob, Daleure, Solovieva, Minhas, and White (2023) acknowledged the findings of some studies that, the lecturers' challenges were among others, the lack of pedagogical and technical skills for conducting the program, the increased workload, time devotion and the difficulty in finding the right blend between online learning and face-to-face. This confirms the findings of a study conducted by Teane (2024) that the

acquisition of technological literacy enables teachers and students to engage in online modes of delivery. On the other hand, Pei et al. (2024) warn that instructors must use these communication technologies with caution in blended learning.

The most important advantages of blended learning is that it allows for student flexibility, students can access course materials anywhere, and at any time (Mahomed, 2024). One great benefit of technology-mediated learning is that it affords individuals extended opportunities to acquire the skills and the rich knowledge, hence, it creates a more dynamic and inclusive educational environment. Similarly, Onah, Pang, and Sinclair (2022) note increasing students' autonomy, students' control of the study environment and their studies, and flexibility as some of the advantages of blended learning. Importantly, Bakeer's (2018) findings reveal that there were high levels of satisfaction with blended learning and significant self-reported improvements in the usage of English skills as well as groupwork self-efficacy. This is also confirmed by Suleiman (2018) who noted that studies revealed that blended learning contributed more to students' attitude towards the geography course and positively correlated to students' critical thinking skills. However, Anthony et al. (2019) indicated that students' experiences in relation to technology plays an important role in the satisfaction and acceptance of blended learning. They maintain that the supportive factors consist of self-motivation, engagement time and experience of the students

Besides the great advantages that blended learning presents in teaching and learning, like promoting active learning and student-engagement, it also has some disadvantages. Teane's (2024) study revealed that a lack of resources; like the shortage of data projectors, computers, and other gadgets make the use of online mechanisms challenging. Additionally, access to data and the internet was also a challenge (Teane, 2024). Notably, Wang et al. (2017) found that there is a great demand for information technology skills from both teachers and educational administrators. The findings in this regard are in line with Teane's (2024) findings, the scholar suggests that teachers at higher education institutions must be the first to receive training in online skills.

Interestingly, Teane (2024) maintains that according to Fullan's theory of change, lecturers who adopt the blended learning approach become agents of change. However, Onah et al. (2022) warn that higher education institutions should not expect students to be equally effective in a particular new mode of learning. The scholars further argue that support is required to ensure students' adjustment and the development of their practice of self-regulation for learning.

6. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study has limitations. The researcher limited the search scope because of the heavily reliance on a single database (Scopus). Furthermore, the study was limited to articles published between 2013 and 2024. In addition, only publications in the English language were considered. Therefore, the necessity of conducting periodic bibliometric analysis on blended learning in higher education, cannot be overemphasised. This process might lay a good foundation for empirical research on blended learning in higher education. The researcher is of the view that further qualitative data on students' perceptions of blended learning would ensure valuable contributions to scientific research. As students can play an important role in contributing towards the creation of different teaching models that could be effectively applied in blended learning. It is this kind of research that contributes to relevant interventions towards stakeholders' professional development.

It is recommended that, studies be conducted that would focus on lecturers' and students' views on blended learning in different disciplines, as Apandi and Raman (2020) argue that there are few studies on university lecturers' views on the implementation of blended learning (BL). Furthermore, there is a need for management's continuous support on ICT usage to both lecturers and students, as studies reveal that more support should be provided to lecturers and students, and this influence their perception towards the adoption of blended learning

7. CONCLUSION

To answer the research question, the researcher analysed the data obtained using VOSviewer. Hence, the researcher could identify a large set of the existing trends on blended learning delivery, based on the different or multi-disciplinary research evidence. Lecturers could contribute positively towards students' learning experiences and enhance their academic achievement if they implement the appropriate blended learning approaches. Furthermore, blended learning should be treated as a future mode of teaching and learning. Meaning that, as teachers or lecturers, or any other stakeholder in education, we should not wait for pandemics such as COVID-19 to then transition into other learning spaces. In higher education, blended learning should be used for the realisation of the main aims of education in the 21st century.

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Chapter # 37

PROJECT-BASED TEACHING Insights from Development in Teaching in Construction Management

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ABSTRACT

Future engineers must be fluent in different technologies, methods, and methodologies requiring a high dynamic capability, in opposite to many students' behavior. Project Based Learning, student-centred with a dynamic approach to teaching where students study real-world problems and challenges, aims to increase dynamic capability. This research reports transforming a course in construction management into a project-based approach to stimulate students' intrinsic motivation, i.e. interest in what is learned and the pleasure it brings. Course material has been developed in four rounds, ranging from 2022-2024. Course documentation regarding the execution of the course as well as documented student feedback was thematically reviewed and analyzed relation to the aim of this chapter. The development shows interesting challenges in teaching regarding the balance between showing results from the actual project vs. stimulation of creativity among students. Age and work experience positively affect how the students execute the projects. It also shows the significance of the course framing and variation of project set-ups. Our findings also show values in PBL for students' ability to handle changes in a world with many insecure influences and it is indicated that PBL requires a learning process over time both for students and teachers.

Keywords: project-based learning, problem-based learning, intrinsic motivation, flexible learning.

1. INTRODUCTION, MOTIVATION AND OBJECTIVES FOR THE

The authors of this chapter have extensive experience in teaching including different subjects at different university levels. These experiences and discussions with colleagues indicate that students are becoming less focused on educational exploration and critical thinking. In this chapter, the focus is construction engineering. Broo, Kaynak and Sait (2022) highlight that future engineers must be fluent in different technologies, methods, and methodologies and the Architecture, Engineering and Construction sector is no exception, where climate impact pressures and technological advancements sets demands on broad skills among its professions (Chacón, 2021). Hence, fast shifts in the surrounding world cannot always be foreseen and puts emphasis on a high dynamic capability, i.e. to adapt to upcoming circumstances to be competitive (see for example Meier et al, 2023) among the workforce of tomorrow. The construction sector in total has faced different waves of changes pushing development forward. For example, digitalization and development of digital tools has put pressure on the sector to change (Jacobsson & Linderöth, 2021). Another current pressure relates to increasing the sectors sustainability. The environmental dimension is for example under scrutiny since the sector contributes with 25 % of the total environmental impact (Ness & Xing, 2017; Wouterszoon Jansen, Van Stijn, Gruis, & Van Bortel, 2020), leading to several

different activities and initiatives taking place to reduce impact, for example use of more sustainable materials and reduction of traditional materials with higher environmental impact. Hence, construction engineers for today and tomorrow face a dynamic environment with a significant pressure to develop solutions for the future.

In this setting and under these circumstances, Project Based Learning can be a valuable teaching approach. This is, in its essence, student-centred with a dynamic teaching approach, where students study real-world problems and challenges (Kokotsaki, Menzies, & Wiggins 2016). According to Bradley-Levine and Mosier (2014) the focus in PBL is besides the students learning to apply knowledge and skills in projects. The learning process revolves around some type of open-ended question connected to current and relevant issues or problems. Students must take an active role in their understanding of related issues and students should be stimulated towards a life-long interest in learning. A typical project can be to start with some type of demand that needs to be fulfilled with frames that the students must keep within, then the students actively, through the support of a teacher works forward to narrow down the demand into a solution. A similar approach to this is Problem based learning, in which complex real-world problems are in focus to promote student learning, i.e., both concepts can promote the development of critical thinking skills, problem-solving abilities, and communication skills and possibilities to work in groups (see for example De Graaf & Kolmos, 2003). Perrenet, Bouhuijs, and Smits (2000) states that a similarity between the concepts is that they both emphasize self-direction, collaboration, have a multidisciplinary orientation and are founded in real-world problems. Hence, both approaches can be valuable in addressing challenges with students and their learning focus, as stated above. However, in this paper, project-based learning is the concept used, abbreviated as PBL. It can also be lifted that there are different ways of creating knowledge from real-world problems. Collins and Redden (2020) for example report on valuable experiences from experiential learning in construction engineering education, where students learn from making real construction work in relation to more theoretical exercises and state the need for understanding construction in practice. Hence, teaching methods with a close connection to real work can be useful to enhance understanding among students.

PBL accommodate demands on both teachers and students. PBL must align with the teachers philosophy of teaching, besides meeting other significant areas such as learning needs (Liu, Wivagg, Geurtz, Lee, & Chang 2012). Grant (2002) highlights the significance of the teachers experience as a supporting factor for PBL. Compared to traditional teaching, the roles of both the teacher and the students change. A stepwise implementation enables teaching to develop in a more controlled way and the balance between student independence and support can be challenging (Marx, Blumenfeld, Krajcik, & Soloway, 1997). Martinez (2022) presents a similar view and states that knowledge and confidence in the design of the actual course taking place is important also implying a wide knowledge base as useful for a PBL approach. Grant also raises the importance of supporting the students interaction and also to handle conflicts. Ertmer and Simons (2006) also pinpoint that the creation of a culture of collaboration and teamwork can be a barrier as well as changing from an instructive to a facilitative role. Other barriers raised by Marx et al. (1997) is that project planning can be time-consuming, disorderly classrooms and that authentic assessments can be difficult to design.

Based on this background, this paper presents documented experiences involved in moving from a traditional teaching approach into a project-based approach regarding a course in construction management, undertaken four times with a new structure in which a PBL approach were developed. The paper aims to provide learnings for other types of education aiming to transform into this type of education based on the stated necessities and driving forces in the background. An overarching objective with this is to provide learning experiences for teachers wanting to develop their teaching with a PBL-approach.

2. METHOD

The results section of this chapter has two parts relating to the aim of this paper. The first part describes the origin for the change of and implementation to enable PBL and how it was designed. Since one of the authors of this paper handled this process, the description is done based on the same authors view about changes that were made, supported by reviewing different type of course documents. The second part of the results section describes how the course rounds were perceived and what kind of feedback the students provided. How students provided feedback is presented in the next paragraphs. In addition, the mean age and experience of the student groups are described, since changes in perception and action was identified as different depending on these issues

For Higher Vocational Education (HVE, see below under 2.1), the students had, as a part of the course assignments, to describe their learning process over the course, write a diary, and evaluate the execution of how the project group had been working together. In this, there was feedback on the course set-up and development. In addition, an evaluation was made by the program director, and the students filled out a formal survey. For Halmstad University (HU, see below under 2.1), the students were given an assignment to write a diary and an evaluation of the project and the project group. In addition, the students did a course evaluation at the end. Besides that, a structured evaluation was made in class to discuss the course and its execution in the final class. Altogether, the documentation of these activities is used to identify areas of improvement for the next round and is on an aggregated level which the students know that it is used for.

The findings is a result from studying the collected material through a thematic review and analysis, to find patterns and significant results in the data in relation to the aim of this chapter. Since one of the authors has been active in the development, this influences the interpretation of the development, and the information presented in this paper. However, the authors have aimed to provide facts that could be viewed as both positive and negative to create trustworthy results. In addition, the second author takes on an important role as critical reviewer besides giving the perspective of an outside view. This is a major part of creating credibility in the results, including reflection of the methods weaknesses and risks (Maxwell, 2012). The critical awareness of the method is also important to create trustworthiness, and here, the outside view of the second author is of central importance (Merriam, 1994).

3. DEVELOPMENT OF THE COURSE(S) IN CONSTRUCTION MANAGEMENT

In this section, the background of the course is described, as well as changes made over the different course rounds. The course has been given at two schools in different rounds, where the content differs due to level and overall education objectives.

3.1. Background and Changes to the Course

Several years ago, one of the authors worked heavily with transforming different engineering education programs from mostly so-called traditional teaching into a teaching approach based on project-based and problem-based learning. This covered half the teaching over one semester in each year of education. Experiences from this were overall sound, and some students already in the first semester produced impressive results in their projects and abilities to bring unexpected ideas and solutions. This positive experience has, from then on, been more or less a key ingredient in one of the author's teaching.

Regarding the Construction Engineering program at Halmstad University, there has been a discussion about how the development of teaching can be developed into a more problem-based approach and project-based approach, stemming from a discussion about the student's attitude toward their studies. In particular, teachers were experiencing a student attitude aimed at having very precise instructions that could provide answers, which in many cases is typical for courses in design that include dimensioning/calculations. Therefore, a change in the design of studies has been viewed as vital to stimulate explorative learning. The course in question for this paper is a course in construction management, basically covering the steps of building design and all activities needed to hand over a finished building. The course provides an overview of the construction process but does not go into depth in sub-areas since this is covered in other courses. Since the students had been complaining about the course being hard to grasp and lack of practical relevance, this provided a good opportunity to redesign the course. The teachers involved in developing the course over time have an interest in PBL and the experiences of its parts varied. The whole course set-up however, has been overall managed by one of the course teachers. The teachers involved have also experience of the subjects treated both from work-life and research.

In parallel, some of the involved teachers had a similar but shorter course at a 2-year education program, a Higher Vocational Education (HVE). HVE was a two-year education with a more practical orientation and included work practice. This course was given once a year but proved helpful as a first test of a revised course set-up, emphasizing project and problem-based learning. The student population was different concerning both age, no of students and experiences. HVE round one (HVE1) had an average age of slightly over 30 yrs and almost half were women and round 2 just under 30 yrs (HVE4) and around a sixth women. HVE was mainly consisting of students that had worked and came from many different backgrounds, including the construction industry. HU2 had an average age of slightly under 25 yrs and nearly half of the class were women. while HU3 had an average of slightly over 20 yrs with about a third of the class women.

The original courses, called HU, took place at Halmstad University and are part of two types of bachelor-level education programs, and HVE, taking place at the two-year education program mentioned above. HU consisted of lectures and exercises, and the exercises were 1 ECTS, a project assignment of 3 ECTS, and an exam of 3,5 ECTS credits. The project assignment was, in short, to create a document for procurement of a building project; the exercises revolved around using different types of projects and the exam about the course aims. The project covered time-planning and costs associated with the building project, and the course mainly had one day a week dedicated to teaching, while the rest of the time was dedicated to the student's studies. HVE had a bit of another set-up, with three days of classroom activities consisting of lectures and exercises. The whole course was then examined through a written exam.

When changing the courses the main objective was to go through the steps of building an industrial facility, including a warehouse, office, and social spaces. The students had project assignments relating to start-up activities and then had to conduct project activities related to a construction project from start to finish for each week. By doing this, the students should also be trained in visualizing and understanding systems and structures, which is essential in the construction sector (Mastrolembo Ventura, Castronovo, Nikolić, & Ciribini, 2022). In HVE, the students worked with the project, its assignments, and documentation in a PowerPoint presentation, with ongoing presentations of the project activities and feedback provided regarding the assignments. In parallel, the students had individual assignments to hand in each week, which were about answering reflective questions about that week's themes. For the HU course, the basic set-up was the same, but

the students had to conduct a report for the project, including a final presentation of the project. Since the HU course was larger in content and length, the assignments were also more extensive.

3.2. Feedback and Changes Over the Rounds

Each time the course has been executed, there have been changes. The first time the course took place was, as stated above, the HVE1. The second time was at Halmstad University (HU2), the third time at Halmstad University (HU3), and the fourth time at HVE (HVE4).

HVE1: The first time the course took place, it was deemed successful overall as it was considered interesting, but also with many areas the students wished to go deeper into. The course evaluation survey had a response rate of about a third of the class answering and a mean satisfaction value of 4,25 (out of 6). Main comments were that the structure of the learning platform was messy, and to many teachers involved and at times messy with the individual assignments and the communication between the teachers. On the positive side, though, it was good with the individual assignments and the projects. In addition, the course was considered interesting and valuable, and the teacher's knowledge was considered good with many new subjects. Judging from the learning process descriptions, the course was deemed successful overall, with about a sixth of the students disappointed but the rest satisfied (or more). A main reflection from the teachers was that the students were not challenged in different types of designs regarding the facility. It was also concluded that they should be provided costs at an early stage to enable an assessment of the design.

HU2: Based on HVE1, different groups were provided with different demand specifications and a more thorough review of different building systems and costs. It was added to the demand specification that the students should choose a possible customer to adapt the building towards. In this round, they were also given more frames to change the design and evaluate their design regarding cost and climate impact. Many of the student groups made a 3D model of the building in the software Revit, which was a good addition to the projects. A main complaint from the students was too much information and sources available and the extent of the report was hard to assess. Otherwise, the groups presented buildings with different designs/architecture. In the oral evaluation the amount of material was discussed, pointing at the necessity for students to learn how to find facts. The course evaluation had a response rate of about a third of the students answering and a general satisfaction index of 67 % (out of 100 %) On the positive side, the students found that the project and the exam were good and interesting, including the set-up with weekly assignments. Once again, the students complained about the learning platform's structure, and some thought the amount of work was too much, although a majority assessed it as fair.

HU3: This time, a demand specification was added to broaden the scope of buildings. In addition, a template with headlines and additional instructions was added to clarify the content of the report and the project. Making a 3D model using the software Revit also became mandatory. In the oral evaluation, students again raised the issue of too much material, once again with the point being that the students need to learn how to find facts. The course evaluation had a response rate of about a fifth and a general satisfaction index of 61 %. Once again, the students found that the project and the exam provided an understanding of all the parts of a project and that the high amount of practical work was good and interesting, including the set-up with weekly assignments. Also, the students complained about the structure of the learning platform and that the students found that the teachers were not synced, which had to do with a new teacher coming into the course previously unused to the course and its set-up.

HVE4: The added changes were used again, this time in the project. In addition, due to previous criticism, the main author took over more of the course to manage a more significant part of the course. Since these students studied a limited version of the project, the visualization in Revit was not part of the project, and some of the parts were smaller in the project. Again, the course was deemed successful overall as it provided good basic competence and many good learning areas, but more depth in some areas was stated as helpful. The course evaluation survey had a response rate of around 70 % and a mean satisfaction value of 4,7 (of 6). Some individual comments were that some parts could have a higher pace, and some students still felt that too many teachers were involved. However, judging from the learning process descriptions, all course participants expressed satisfaction with the course.

Planned for next round was that the students were given a real area to plan the building project on. The area was under planning within a municipality, where the buildings in the projects can be built. This addition was made to further enable different types of designs and projects and possibly also add possibilities for different types of architecture.

4. DISCUSSION AND FUTURE RESEARCH DIRECTIONS

Regarding the development of the course, the set-up has been in line with the teachers view of teaching (c.f. Liu et al., 2012). Experiences of PBL has though varied, but in this case mixed experiences have been useful. In line with Martinez (2022), the teachers' different experiences and interests have complemented each other and has enabled the execution in a satisfactory way. One of the key issues at hand with the course was to develop it and stimulate students' interest in the course subject, intrinsic motivation (Entwistle, 2009), i.e., motivation that comes from "*interest in what is being learned and feelings of pleasure derived from it*" (pp 20), and not from external rewards (extrinsic motivation). As seen from the evaluation summaries, there is a variance regarding students' satisfaction. An indication is, however, that older and more experienced students seem to cope with the approach better than younger students. This strengthens the fact that interaction and self-direction is important and needs extra support when needed. However, there is still a dilemma with several issues in the approach. Firstly, the structure of information can constantly be improved. However, the balance between providing very clear instructions and letting the students set the frames themselves seems to be an ongoing development route where more clarity can be improved, but the level of innovativeness in the projects must also be supported and encouraged. I.e., this highlight that a balance between student independence and support can be challenging. It is however also clear that students need to be taught into the teaching approach, validated by the ongoing discussions held between the teachers involved, highlighting the students' preferences to traditional teaching. This is furthermore validated by the older students ease to work with PBL. Hence, it is about learning to learn according to PBL, which has been discussed as a way forward by the students. It also shows a connection the significance of learning from past experiences as stated in experiential learning (cf. Collins & Redden, 2020).

An example is that the students initially think the project is unclear, but it becomes more apparent as they go ahead. This phenomenon seems to be more stressful for younger students than older ones, and younger students ask more questions regarding what to do. In contrast, older students ask more questions about knowledge and its application. The students experience the setup differently depending on personal attributes and experience. At large, the HVE students generally, although being a smaller group, seem to have a greater interest in learning. In addition, the impression is also that they can manage undefined issues better

than university students, which most likely can be related to their experience in managing issues in real life. Hence, in this case it does not seem as if they are taught to search for knowledge, it is their responsibility to find it and they show this through their attitude. It can also be assumed that the older students through their work-life have a wider knowledge base that they can use, quite logically since real-world-problems are in focus when working practically. Hence, older students with work experience seem to have learnt how to work according to PBL, while younger students need to learn this and get used to not everything being clear at once.

There is also a challenge in how many teachers should be involved, and an easy conclusion seems to be that one teacher should have a majority of the course, validated by HU2 and HVE4 just to create a good thread through the course, but a set-up with different competences also provides a larger knowledge base for the students. A reflection is however that since this course is of a more basic level, students might appreciate a logic and coherent thread through the course instead of having many competences available, which might be more useful in a more advanced course. However, there is also a learning process among teachers to get into the approach, which is also valuable. As stated above, the number of teachers is also in direct correlation with the access to a larger knowledge base for the students. Reviewing the implementation process and the developments taking place over time, stepwise development and changes have taken place as in line with Grant (2002) and Martinez (2022). We can however also see that there is a new population coming in for every occasion of the course, implying that the same approach would have been useful for the same set of students over several courses. It is however apparent that the experience and maturity of the learners plays a decisive role in the execution of the courses.

Obviously, there are several ways to conduct research but if development proceeds this is one way forward. It could also be of interest to do more active research during the courses take place and interview students and teachers about how the course takes place and how it proceeds according to barriers and enablers raised in this chapter. Another way forward of interest is to explore the long-term impact of PBL for students taking part in the education, by interviewing these when they have work-experience and their reflections from a long-term perspective. It would be especially interesting to conduct a follow-up with the younger students after a few years work-experience and see if the age difference-impact on learning would be validated and receive feedback on how to design the teaching.

5. CONCLUSIONS

Based on previous experiences from project-based learning, course material has been developed in four rounds in a course in construction management. The course has revolved around a construction project. A main driver has been to increase creativity and variation in the projects but also to meet the students' wishes to improve the course. Working with problem-based and project-based learning is a learning skill, and handling undefined activities is a competence that also needs to be developed to manage changes in a real-life work environment. Development in steps as well as having teachers with PBL-knowledge is a significant factor to develop in line with having a fundamental interest in the teaching approach. Hence, the study provides an example of development work and experiences, which other working with PBL can learn from.

The course focused on an already conducted construction project, which was modified for each round so the students could create new frames for the project. Feedback was received during the course, and individually, students at the end of the course provided feedback to coming rounds. The results from this development show interesting challenges in teaching

regarding the balance between showing results from the real project vs stimulation of creativity among students, with a clear conclusion that age, and work experience have a positive effect on how the students execute the projects, I.e the character of the population is decisive but also the ability to use the approach over several courses to develop the extent of PBL. It also directly shows the significance of the course framing and the variation of project set-ups in the course. Our findings also show values in PBL for students' ability to handle changes in a world with many insecure influences. It should also be acknowledged that learning among teachers is also a significant part of the development process. The wide frames of the set-up seem to stimulate creativity but also need to be balanced with good enough instructions. Based on the research presented, learning to learn with a PBL-approach also requires time to master, for both students and teachers, preferably on several occasions over time.

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Chapter # 38

EXPLORING THE SUPPORT NEEDS OF TEACHERS IN FULL-SERVICE SCHOOLS TO PROMOTE INCLUSION

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ABSTRACT

Supporting teachers in full-service schools (FSSs) is important in the South African education system as it enhances education for sustainable development. Although teachers have undergone pre-service and in-service training as part of support in inclusive education, it is apparent that they do not receive adequate support to teach in inclusive classrooms. Entrenched within the qualitative approach and the interpretivism paradigm, the study allowed teachers to construct reality in terms of their support needs. 12 participants from two full-service schools in the North-West Province were purposively sampled. Data were generated through semi-structured interviews and were thematically analysed. The findings indicate that continuous practical training is their key need for support. Availability of the teaching and learning resources, participation in Professional Learning Communities (PLCs), and intentional support by the support structures were highlighted as other support needs of teachers in full-service schools. In addition, adequate collaboration with the key learning support stakeholders was highlighted as a support need in inclusive education settings. It is recommended that the School Management Teams (SMTs), School-Based Support Teams (SBSTs), and District-Based Support Teams (DBSTs) should ensure that teachers are trained theoretically and practically on a continuous basis to maintain inclusive pedagogies.

Keywords: full-service school, inclusion, instructional pedagogies, support needs, support services, teachers.

1. INTRODUCTION AND BACKGROUND

Globally, Inclusive Education (IE) was initiated as a result of the worldwide conference on Special Education that was held in Salamanca in 1994. The Salamanca conference proposed that all educational systems worldwide should be inclusive of varied learner diversity (United Nations Educational, Scientific and Cultural Organization [UNESCO], 1994). In essence, IE should provide equal educational opportunities for all learners, regardless of their inabilities, abilities, backgrounds, gender, sexual orientation, and religion. Internationally, IE policies regard a teacher as the key and primary stakeholder in implementing inclusion (Adewumi & Mosito, 2019; Ayaya, Makoelle, & Van der Merwe, 2020; Chow, 2023). Like other countries, South Africa, as a signatory of the Salamanca statement and framework on special needs education (Engelbrecht, Nel, Smit, & Van De Venter, 2016), agreed to the call to adopt an inclusive education system.

In South Africa, the Education White Paper 6 on special needs education (Department of Education [DoE], 2001) was specifically promulgated to guide the implementation of an inclusive education system. It was in this inclusive policy that the South African Education system was divided into three categories of schools namely, ordinary or mainstream schools, Full-service schools (FSSs) also known as inclusive schools, and Special Schools as Resource Centres (SSRCs) as a strategy of ensuring inclusion in schools (DoE, 2001).

This means teachers teaching at all types of schools should embrace inclusive practices in their instructional pedagogy. According to UNESCO (1994), inclusive schools should offer quality education for all learners, including learners with disabilities, thereby enhancing education for sustainable development. However, for teachers to fully embrace inclusive education practices, their support needs should be prioritised.

International and national inclusive policies emphasise the need for teachers to be supported. For example, the Salamanca Declaration (UNESCO, 1994) highlighted that teachers should be supported in inclusive educational settings. South African Education White Paper 6 stipulates that teachers should be supported to enhance the implementation of inclusive education practices (DoE, 2010). White Paper 6 called for the establishment of Support structures such as School-Based Support Teams (SBST) and District-Based Support Teams (DBST) to provide support to teachers and learners in South Africa (DoE, 2001; Adewumi & Mosito, 2019). In addition, the Screening, Identification, Assessment, and Support (SIAS) policy guideline further emphasised the provision of support to teachers as an enabler of inclusive pedagogies within classrooms (DBE, 2014). However, it seems the support needs of teachers in inclusive schools are still not prioritised. This is because the literature highlights that teachers in South Africa are still challenged to foster and maintain inclusive pedagogies (Mpu & Adu, 2021).

Teacher support is significant in the teaching profession across the world. Generally, teachers require support as they navigate the profession (Nkambule & Amsterdam, 2018) and implement various educational policies. Department of Education (1997) in the Report of the National Commission on Special Needs Education and Training (NCSNET) postulates “support” as an enabling mechanisms that ensure responsiveness in addressing the needs of learners and teachers within an inclusive education system. The report outlines the enabling mechanisms to include Education Support Services (ESS), ranging from teaching and learning support interventions, social support interventions, parental support, various forms of therapeutic support, teacher training and support, and curriculum development, to name a few. In their study, Nkambule and Amsterdam (2018) pointed out that teacher support includes activities such as mentoring, coaching and professional development. Cambridge Online Dictionary (2022) defines a “need” as a thing an individual must have to have a satisfying life. This means that a need is a necessity or a must-have. Thus, in the context of this study, support needs are defined as the interventions, activities within and outside the school environment that teachers require to enable them to thrive in inclusive schools. Thus, the availability of required support may assist teachers in adopting inclusive instructional strategies that would improve the educational outcomes of the learners.

2. SIGNIFICANCE OF SUPPORTING TEACHERS IN INCLUSIVE SCHOOLS

Supporting teachers is important to enhance the quality of instruction, improve educational outcomes, and ensure that teachers are well-prepared to manage their professional responsibilities. Teachers who receive continuous professional development training and are provided with sufficient teaching and learning resources have high levels of self-efficacy in teaching inclusive classrooms (Van Staden-Payne & Nel, 2023; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). Furthermore, teachers need support systems and structures that provide them with opportunities to join Professional Learning Communities (PLCs) and mentorship opportunities so they can teach in inclusive classrooms with confidence (Duncan, Punch, & Croce, 2021). Yu and Chao (2022) maintained that continuous involvement in professional learning communities encourages

knowledge sharing and the exchange of ideas in a safe environment. For example, some teachers wish to be professionally trained so that they can be well-equipped to deal with the social skills of learners with Autism Spectrum Disorder (ASD) and learn appropriate skills on when and how to intervene (Chow, Bruin, & Sharma, 2024). This implies that the professional training of teachers in inclusive schools should be critically considered to enhance their efficacy in performing their allocated duties. Teachers may also benefit more if they get more human resources, such as teaching assistants. Chow et al. (2024) argue that the support from teaching assistants would relieve teachers and grant them an opportunity to deliver the curriculum in such a way that caters to and accommodates all learners in the classroom.

It is reported that in inclusive schools where support structures and school leadership and management provide teachers with the necessary support, maintaining inclusive pedagogy becomes easier to uphold (Duncan et al. 2021). Kugelmass and Ainscow (2004) affirmed that the active involvement of leadership in inclusive schools enhances equity and provides quality education for all learners. Hence, the school leadership and management should ensure that appropriate training and teaching resources are available for teachers to be competent in inclusive classrooms (Dickson, 2014). Nel, Engelbrecht, Nel, and Tlale (2014) further reported that collaboration that includes support structures is paramount in implementing inclusive education practices. However, the literature indicates that the support structures are not effective in their support role (Nel, Tlale, Engelbrecht, & Nel 2016). Thus, Chow (2023) argued that it can be challenging and daunting to teach in an inclusive education setting for teachers who do not have support.

3. CHALLENGES OF TEACHING IN INCLUSIVE CLASSROOMS

Teaching in inclusive classrooms can be overwhelming and stressful at times. An inclusive classroom means that all the learners should be fully engaged to receive the quality education that would be achieved through full participation in classroom activities (Ngadni, Singh, Ahmad, & Baharudin, 2023). The conditions for teaching and learning, such as huge workloads, overcrowded classrooms, insufficient resources, lack of training, and time constraints (Adewumi & Mosito, 2019), hinder the effective implementation of inclusive pedagogies needed in inclusive classrooms. As the classrooms become more diverse, teachers face increased challenges in managing different learning styles, cultural backgrounds, and special educational needs. In addition to the challenges highlighted earlier, a lack of collaboration among and between stakeholders in the implementation of inclusion is reported by various scholars (Ayaya et al., 2020; Chow et al, 2023). Van Staden-Payne and Nel (2023) reiterated that inadequate training of teachers, the ineffective functioning of the support structures, the incompetence of the school management team, lack of parental involvement, and inadequate resources contribute to ineffective instructional pedagogy in inclusive schools. In her study, Engelbrecht (2020) pointed out the lack of appropriate infrastructure and sufficient funding as some of the challenges experienced in implementing inclusive teaching practices. Thus, as a result of the outlined challenges, teachers working in inclusive schools experience stress and burnout, especially those who are not specialists in the field of special educational needs (Candeias, Galindo, Calisto, Borralho, & Reschke, 2021). The literature further indicates that teachers experience higher levels of stress (Gray, Wilcox, & Nordstokke, 2017; Räsänen, Pietarinen, Soini, Väisänen, & Pyhältö, 2022) due to the varied challenges that they face in the profession, especially those who are working in inclusive schools. We, therefore, argue that a snapshot of these challenges may shed light on the support needs of teachers in inclusive schools.

4. STUDY OBJECTIVE

This study sought to explore the support needs of teachers in Full-Service Schools to promote inclusion. To successfully achieve this objective, this study was guided by this research question: What are the support needs of teachers teaching in full-service schools in South Africa?

5. THEORETICAL FRAMEWORK

The transformative learning (TL) theory that was developed by Mezirow (1978) was used as a theoretical framework for this study. Mezirow defined TL as ‘learning that transforms problematic frames of reference—sets of fixed assumptions and expectations (habits of mind, meaning perspectives, mindsets)—to make them more inclusive, discriminating, open, reflective, and emotionally able to change’ (Mezirow, 2003, p. 58-59). As a framework, the transformative learning theory explores how people evolve their understanding and worldview (Rodríguez Aboytes & Barth, 2020) through critical reflection and new information that they have received. In this study, the transformative learning theory was used to explore the challenges, and the support needs of teachers in full-service schools. This means teachers’ experiences can be used as a benchmark to shape and transform practice through the realisation of their support needs. Thus, transformative learning involves epistemological change (Rodríguez Aboytes & Barth, 2020) where teachers examine and reflect on their support needs.

6. METHODOLOGY

Embedded in the interpretivism paradigm, the study sought to explore the support needs of teachers in inclusive schools. Interpretivist researchers emphasise that the world could be best understood through first-hand experience of the insiders’ perspectives (Creswell & Poth, 2018). Alharahsheh and Pius (2020) also argue that with interpretivism, researchers can benefit from getting in-depth meanings from the participants. A qualitative research approach was used in this study to gain insight into the support needs of teachers in inclusive schools. Furthermore, this research approach allowed the investigation of the phenomena in a real-world setting (Adeoye-Olatunde & Olenik, 2021), which produced in-depth knowledge of the support needs of teachers in inclusive schools. Purposive sampling, which aims to identify participants with the same experiences as the central phenomena of the study (Patton, 2015; Thorne, 2016), was used to recruit 12 participants from two full-service schools in the North West province. This sampling procedure allowed for the identification of participants who contributed to the shared understanding of the required support needs of teachers in the FFS. Data were collected using semi-structured interviews. Adeoye-Olatunde and Olenik (2021) argue that semi-structured interviews permit interview questions to be focused to further enhance understanding of phenomena. Semi-structured interviews were the preferred data collection method as the aim of this study was to better understand teachers’ support needs. Braun and Clarke’s (2014) six-step thematic data analysis method was used to analyse data. Ethical approval to carry out this study was granted with the ethical approval number (N W U - 0 0 4 1 3 - 2 3 - A 2), and the adherence to respect for participants, anonymity, and confidentiality was safeguarded.

7. FINDINGS AND DISCUSSION

The findings of the study are presented and discussed in this section. Six main themes that emerged during the data analysis process are outlined. Quotations and excerpts representing each theme are presented. Pseudonyms are used to safeguard the identity of the teachers. The six themes that emerged in this study included the teachers' understanding of support needs, continuous practical in-service training, availability of teaching and learning resources, adequate collaboration with the key learning support stakeholders, intentional support by the support structures, and participation in Professional Learning Communities.

7.1. Teachers' Understanding of Support Needs

Teachers showed an understanding of support needs based on their experiences of teaching in inclusive schools. This is evidenced in the excerpt below:

Support needs include a lot of things. As teachers who are working in inclusive schools, we should get support from the district office. (Pheliwe)

We work with learners with diverse needs, we sometimes feel overwhelmed. We need some therapeutic support. Some students drain us emotionally. At times, we do not know what to do with some learners who are in our classrooms. We need holistic support. We should also be trained regularly. (Zakhele)

It is evident from the participants' responses that they understand their support needs. Precious was able to elaborate on support needs as she said:

The Department of Education is not considering our holistic well-being. They just want us to work under so much pressure, to meet deadlines, but they are not giving us support. They should empower us through training. (Precious)

This finding indicates teachers' understanding of their support needs, which includes the need for holistic support from the support structures and the need to be trained on how to deal with learners with diverse needs. These findings of the study resonate with the definition provided by the DoE (1997) Report of the National Commission on Special Needs in Education and Training (NCSNET), which outlined support as the enabling mechanisms, including teacher training and support. The enabling mechanisms enhance the addressing of learners' and teachers' needs within the inclusive education system. In narrating their support needs, teachers conformed to the proposition of transformative learning theory, which allows people to understand what is happening around them through critical reflection of their practice (Rodríguez Aboytes & Barth, 2020).

7.2. Continuous Practical Teacher Training

Teachers emphasised the need for continuous teacher training as it is key and may assist them in effectively teaching and supporting the learners in the diverse classrooms. This is evident in the following excerpt:

Yes, there is training provided in our school, which is important in our profession and for our school and learners, but the training is seldom, as a result, we do not feel supported enough. The training is mostly theoretical, I think the department and the support structures can do more. (Zakhele)

Siyanda also echoed the same sentiments by indicating the following:

Training is provided by the departmental education specialists, but you know the training is not enough. Last year, when I went for training, it was for two days only, and it focused on supporting learners with Attention Deficit Hyperactivity Disorder... you see, this training is needed, but we were not trained on how to complete the learning support referral form after identifying these learners. I wish the training could be more frequent and more practical. (Siyanda)

From the above findings, teachers propose continuous teacher training as their support need. They further indicated that the training should be as practical as possible. This means that teachers are emphasising that the training should not be an occasional, once-off intervention but rather should be as frequent as possible. In addition, the continuous training should align with the needs of teachers and strategies on how teachers can ensure that their classrooms are inclusive. This support for continuous training is congruent with the findings reported by Van Staden-Payne and Nel (2023), who reported that the training of teachers in inclusive schools is inadequate. This finding further aligns with Chow et al. (2023) views who reported that continuous teacher training is perceived by most teachers as the support needed within inclusive education settings. However, the literature is silent regarding the practical component of the training provided.

7.3. Availability of Teaching and Learning Resources

Teachers mentioned the need for teaching and learning resources for the learners to fully benefit from their learning experiences, as expressed by Sibusiso and Bulelwa in the excerpts below:

Resources are key. As a teacher, I can do my best, but when the learner does not have an assistive device, it means they may not access learning fully. So, it is a problem. At least the school management and the DBST should prioritise the assistive devices for the learners (Sibusiso).

At my school, we have many learners in the foundation phase, but there are no teaching assistants. I wish we could have these assistants so that they can assist us in supporting the learners with barriers to learning. You know if you have many learners in your classroom without a teacher assistant, you struggle to give attention to learners who may need support (Bulelwa).

The above findings depict that teachers recommend prioritising the availability of teaching and learning resources to improve instructional pedagogies. This finding further indicates that the availability of teaching and learning resources should not be for the benefit of teachers only but should be available for the benefit of learners as well. This could ensure and promote access to quality learning and improve educational outcomes. This finding corresponds with the findings by Adewumi and Mosito (2019) and Engelbrecht (2020), who reported that teachers need teaching and learning resources that may enhance inclusion. The provision of teaching and learning resources may allow teachers to be creative and conform to inclusive teaching practices.

7.4. Adequate Collaboration with Key Learning Support Stakeholders

Teachers mentioned that they are collaborating, but they feel that the collaboration is inadequate, and it is not always timely. See quote below from Precious:

Collaboration is there... I collaborate with other teachers; I involve learners, but parents are not always available for interventions. My challenge is that the collaboration does not involve other key stakeholders like parents. (Precious)

In addition, Pheliwe echoed similar sentiments by indicating the following:

Stakeholders do not always respond to intervention requests promptly. Yes, they respond, but sometimes we wait the whole year waiting for the intervention from the education specialists working at the district office. (Pheliwe)

The finding above indicates that there is collaboration between teachers, learners, and district officials. However, parents as partners in education are often not available for the interventions. In addition, there are delays in attending to the interventions by the district officials. Therefore, the collaborative partnership as a cornerstone of inclusive instructional pedagogies is inadequate. This finding highlights the unsatisfactory collaborative partnerships between teachers, parents, and district officials, which sometimes delay support provision. This makes it imperative for the support structures to support teachers in ensuring that all key stakeholders play their effective role in ensuring inclusive pedagogies in schools. This finding corroborates the view of Adewumi and Mosito (2019), who opined that strong and effective collaboration among teachers, parents, and other key stakeholders should be encouraged in the implementation of inclusive practices. Similarly, Nel et al. (2014) reported that collaboration that includes support structures is paramount in implementing inclusive education practices.

7.5. Intentional Support by the Support Structures

Teachers indicated that their classroom would display inclusivity if the support structures were intentional about ensuring inclusivity and actively involved in supporting them to effectively practice inclusive pedagogies. These support structures include members of the SMT and SBST, such as principal and departmental heads. Bulelwa expressed the concern in the following manner:

Our SMTs, I mean my head of department, is not supporting properly to ensure inclusivity in the classroom. They allocate many learners to one classroom, yet they know that we have to prioritise learner engagement in our classes. My view is to be inclusive, I need to actively engage all learners, but how do I do it if there are 65 learners in my class? You see, it becomes challenging. I feel they should be considerate and reduce the number of learners they allocate to us. (Bulelwa)

Moreover, Zakhele echoed his sentiments using the below excerpts:

In my school, the principal talks about inclusivity but does not support us enough. At least every quarter, she could check with us if we need any training support so that she can communicate with the district about our training needs. We struggle alone in diverse classrooms. (Zakhele)

These findings indicate that SMTs are aware that classrooms should be inclusive, but they are not intentional in supporting the teachers. Literature highlighted the active involvement of the management and leadership of the school to be effective in the

implementation of inclusive education practices. For example, Kugelmass and Ainscow (2004) viewed the active involvement of leadership in inclusive schools as enhancing equity and providing quality education for all learners. Furthermore, Lambrecht, Lenkeit, Hartmann, Ehlert, Knigge, and Spörer (2022) also reported that the active involvement of school leadership in the implementation of inclusive education is crucial in inclusive schools. Consequently, these findings call for the intentional and active involvement of the relevant support structures in an inclusive education system.

7.6. Participation In Professional Learning Communities

Teachers mentioned that they wish to participate in professional learning communities continuously to enhance inclusive pedagogies and collaboration with other teachers. This was mentioned by Sibusiso as follows:

You know there are professional learning communities within my subdistrict. It is good, but it was going to be beneficial if this could be done as a formal intervention, which also has input from experts. The PLC should be used as a mandatory continuous professional development programme and not a voluntary once-off initiative. This will encourage continuous collaboration and sharing of best practices. (Sibusiso)

The above findings indicate that professional learning community initiatives are not mandatory. Therefore, making them mandatory may enhance collaboration and the sharing of best practices. This is because PLCs are excellent at creating inclusive practices where teachers can discuss and share best practices in enforcing inclusive pedagogies. This finding corroborates the findings reported by Duncan et al. (2021), who maintained that involvement in professional learning communities is proven to be effective when it is sustained. It can further improve and support teachers' inclusive education capacity building. Similarly, Yu and Chao (2022) reported that continuous involvement in professional learning communities encourages knowledge sharing and exchange in a safe environment.

8. FUTURE RESEARCH DIRECTIONS

Future research could focus on the efficacy of continuous practical, formal, and informal training and the adequate collaboration practices that are highlighted as support needs in this study. The focus could also be expanded by including the voices of support structures, especially the SBST and the DBST, in identifying the support needs of teachers in full-service schools based on their involvement in supporting teachers.

9. CONCLUSION

The study explored the support needs of teachers in full-service schools, which is critical for enhancing education for sustainable development. The literature highlighted the significance of the support needs of teachers in inclusive classrooms. This study confirms that teachers are not receiving enough support to teach in inclusive classrooms. The findings indicate that the teachers in full-service schools require continuous practical professional development interventions. Therefore, it becomes evident that teachers recognise the value of embracing lifelong learning through continuous professional development initiatives. This can help in enhancing their well-being and allowing them to thrive in full-service

schools. Availability of teaching and learning resources, intentional support by the support structures, adequate collaboration with the key learning support stakeholders, and participation in the PLCs were also highlighted as the support needs of teachers in full-service schools. The teachers narrated their support needs through reflecting about their current practices and experiences, which aligns with the key assumptions of transformative learning theory. It is recommended that the SMTs, SBSTs, and DBSTs should ensure that teachers are trained continuously on theoretical and practical strategies that enhance inclusive teaching practices. Furthermore, support structures should be intentional in providing support to teachers. The findings of this study can be used by the Department of Education's capacity-building personnel and support structures to develop support programmes that are continuous and sustainable for supporting teachers in full-service schools. These findings should not be generalised because this qualitative study was undertaken in two full-service schools in the North West province of South Africa.

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Chapter # 39

SCREENING FOR MATHEMATICAL DIFFICULTIES: ELABORATION AND PILOT STUDY

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ABSTRACT

In Brazil, there are few studies about identification and early intervention of difficulties in mathematics. Objectives: To develop a screening tool to identify students at risk for mathematical difficulties in the initial literacy series and to verify the applicability of the screening elaborated. Methods: From a bibliographic survey, 8 mathematical skills were selected based on the Triple Code Model to elaborate a screening program composed of number sense, number line, place value, addition, subtraction, multiplication, division and problem-solving skills. The screening was applied in four 45-minute sessions, twice a week, during class time. A total of 201 students from the 1st and 2nd grades of elementary school were evaluated. Of these, 44 students were identified as at risk and referred to the remediation program. The study showed the need to reduce the number of skills to 5: number sense, number line, place value, addition and subtraction. This reduction occurred due to the observation that knowledge related to addition and subtraction should be developed first. Conclusion: The adjustments made based on the results of the pilot study will favor the application of the screening to better identify students with difficulties in mathematical skills.

Keywords: learning, screening, skills, mathematical skills.

1. INTRODUCTION

Every student need and deserves to have knowledge, comprehension and competency to be able to acquire mathematical learning. However, many students show difficulties in mathematical learning according to data presented in the Results Report of National System of Basic Education Evaluation (SAEB) in 2019 (National Institution of Study and Educational Research Anísio Teixeira, 2023; Powell & Fuchs, 2015).

The early identification of these mathematical difficulties may detect students who need educational support or intervention before the learning difficulties occur (Jordan, Kaplan, Locuniak, & Ramineni, 2007). This early identification can be done through a diagnostic of mathematical skills which helps teachers identify the strong and weak points in students and the comprehension of these weaknesses enables teachers to identify and adjust one or more intervention programs that address the difficulties the student presents (Powell & Fuchs, 2015).

Those difficulties may involve one or more areas in Mathematics due to cognitive deficits, inadequate instructions, or a combination of factors (Geary, 2004). Studies have shown that students participating in high quality preventive programs have obtained positive impacts in development and these benefits extend to academic, sociability and employability aspects (Carneiro & Heckman, 2003; Butterworth, 2005).

One of the most cited preventive programs in literature is the Response to Intervention Model (RTI) which also provides early interventions in levels to students at risk of academic

failure (Fuchs & Fuchs, 2006). The RTI model is a multi-tiered system, divided in 3 levels, or three tier: Tier 1 is a universal screening of difficulties in students, and it is performed by everyone in the classroom. Tier 2 is composed by students that showed low performance in Level 1, identified as students at risk for academic learning and in this tier, they start receiving specific, progressive and effective interventions in small groups giving the students the opportunity to develop academic knowledge. Level 3 is for students who don't respond to the intervention in level 2 and need an individual intervention, this time in clinical context, and the risk being confirmed, they are referred to an interdisciplinary team for the confirmation or exclusion of the diagnostic (Andrade, Andrade & Capellini, 2014; Fuchs & Fuchs, 2006).

Therefore, this study is justified by the fact that there is still a gap in studies regarding the response to intervention program with mathematical skills in Brazil, as well as the lack of effective instruments for identification and intervention in students at risk of problems in mathematical learning. This way, the objective of this study was to elaborate a screening program to identify difficulties in mathematical skills in students in early school grades and verify the applicability of a study pilot.

2. BACKGROUND

There is an increasing concern about an early identification of students at risk of difficulties in mathematics in the early years. It is important to identify the predictors of these mathematical difficulties in students so that an early intervention, focusing on these characteristics could be possible. Based on current studies on the predictors of mathematical difficulties, it is now possible to develop early interventions for learning mathematics to prevent and remediate these students at risk of mathematical difficulties (Bryant, Bryant, Gersten, Scammacca & Chavez, 2008a)

To identify these at-risk students, the strategy would be to evaluate all students in the classroom in a screening that shows students who perform below their peers. Once these at-risk students have been identified, they will be selected to participate in tier 2, with evidence-based interventions to prevent these mathematical difficulties (Andrade et al., 2014; Fuchs & Fuchs, 2006). With the premise of identifying these students with learning difficulties, based on screening, with a response to educational intervention inferior to their peers, the RTI differentiates inferior performance by the quality of teaching and the risk of difficulty. If the student presents difficulty in teaching that benefits most of other students, then the problem is not in the quality of teaching but in the difficulties of the student himself (Fuchs et al, 2005). The student at risk is identified based on his/her lack of response to various interventions in educational contexts, and no longer as discrepancies between academic performance and intellectual capacity, but rather by the lack of progress in response to appropriate interventions (Fuchs et al, 2005; Fuchs & Fuchs, 2006)

The RTI, in tier 1, makes it possible to identify students at risk for learning difficulties, considering the risk of dyslexia, dyscalculia and behavioral problems, which do not yet have neurological maturity and have not had adequate opportunities for intervention, as recommended in the Diagnostic and statistical manual of mental disorders (American Psychiatric Association, 2022). These students require preventive interventions before the onset of a greater academic difficulty, providing adequate learning development and academic success (Fuchs et al, 2007b). Screening, Tier 1, focuses on universal design, which should include effective, evidence-based instruction that benefits all students, to identify students at risk for mathematics difficulties (Bryant et al., 2008a; Bryant et al., 2008b; Fuchs & Fuchs, 2006).

In Brazil, the experience with RTI has proven effective in identifying students at risk for dyslexia, with programs focusing on the first layer, tutoring the teachers (Fukuda & Capellini, 2018), the second layer (Andrade et al., 2014; Margutti, Cerqueira-César, & Capellini, 2021) and the third layer (Cerqueira Cesar, Germano, & Capellini, 2018). Also in Brazil, a program was developed with the RTI model for attentional skills, focusing on the three layers (Kerges-Alcantara, Germano, Sillankorva, & Capellini, 2021). Therefore, there was a need to expand studies with the model for mathematical skills, which we are reporting in this chapter.

Studies have shown that basic math skills such as number sense, number lines, place value, addition, subtraction, multiplication, division, and problem solving are predictors of math difficulties (Bryant et al., 2008a; Bryant et al., 2008b; Fuchs, Fuchs, & Hollenbeck, 2007a; Fuchs et al. 2007b; Jordan et al., 2007). Currently, studies such as those by Fuchs et al. (2007a) and Fuchs et al., (2007b) have demonstrated the use of RTI to identify students at risk for mathematics learning.

Some studies demonstrate how tier 1 can identify students at risk for mathematical difficulties and that those referred to Tier 2 interventions can improve their performance in mathematical learning. (Fuchs, et.al 2007a; Powell & Fuchs, 2015). Fuchs et al, (2007a) evaluated, tier 1, through a battery of mathematical assessments, students from 41 first-grade classes, allowing the identification of students at risk for mathematical difficulties based on low performance in the assessment.

Bryant et al. (2008a) identified 126 first-grade students and 140 second-grade students at risk for difficulties in mathematics through a screening that involved a battery of tests involving basic mathematical skills. The identified students were referred to level 2 and underwent interventions that involved initial mathematical concepts and skills, demonstrating a significantly greater effect for second-grade students.

Therefore, developing a screening based on scientific evidence that allows the identification of students at risk for mathematical difficulties, makes it possible to include these students in tier 2 of interventions for better performance in mathematics.

3. METHODS

This study was approved by the committee for Ethics in Research of the University of Philosophy and Sciences – FFC/UNESP – Marília – SP (number CAAE 60381922.0.0000.5406 – opinion number 5.690.282). As procedure, bibliographical research was conducted regarding the theoretical basis to elaborate a screening process to identify difficulties in mathematical skills in students in early school grades.

The databases consulted to elaborate the screening were Pubmed/MEDLINE, SciELO and ERIC and the descriptors selected were listed in the vocabulary indexing of Health Sciences Descriptors, in both Portuguese and English languages combining two terms: Response to Intervention” OR “Remedial Teaching” OR “Remedial teachings” OR “Teaching Remedial” OR “Teachings, Remedial”) AND (Math OR Mathematic OR Arithmetic).

The pilot study was carried out with the objective to verify the applicability of the screening elaborated with 201 students from the 1st and 2nd grade level, regularly enrolled at a public school in São Paulo, Brazil. The screening was applied to all students in early school grades, in four 45-minute sessions, twice a week during class period collectively.

3.1. Objective

Develop a screening tool to identify students at risk for mathematical difficulties in the initial literacy series and to verify the applicability of the screening elaborated.

3.2. Results

In Table 1 we can see the skills that composed the protocol for screening difficulties in mathematical skills formed of 8 abilities: number sense, number line, position value, addition, subtraction, multiplication, division, and problem-solving.

The number sense was composed of 11 tasks and each task was composed of 5 activities; the number line, position value and problem-solving skills were composed of 1 task with 5 activities each; addition, subtraction, multiplication, and division tasks were composed of 2 tasks each, with 5 proposed activities.

Table 1.
Distribution of skills, tasks and activities per school grade level.

SKILLS	TASKS	ACTIVITIES	1st year	2nd year
Number Sense	Magnitude	More points, less points,	x	x
	Cardinality	Correct quantity of objects	x	x
	Ordinality	Position of an object in a conjunct	x	x
	Comparison	Difference in a category	x	x
	Length Measurement	Length	x	x
	Volume Measurement	Volume	x	x
	One to One Correspondence	One to One correspondence		
	Estimate	Approximate quantity without counting	x	x
	Image-Symbol Transposition	Image-Symbol	x	x
	Symbol-Image Transposition	Symbol-Image	x	x
	Verbal number	Name Number	x	x
Number Line	Number Sequence	Number Line	x	x
Position Value	Position - Value	Hundred/Ten/Unity		x
Addition	Addition - Concrete	Concrete - Operations	x	x
	Addition - Operations			
Subtraction	Subtraction - Concrete	Concrete - Operations	x	x
	Subtraction - Operations			
Multiplication	Multiplication - Concrete	Concrete - Operations		x
	Multiplication - Operations			
Division	Division - Concrete	Concrete - Operations		x
	Division - Operations			
Problem-Solving	Problem-solving	Problem-solving involving simple addition and subtraction	x	x

For the screening, 201 students from the 1st and 2nd grade level of Elementary School I participated in the screening to identify students at risk for mathematical difficulties. Of these, 44 students were identified as at risk and were referred to the remediation program. The screening was applied in three 45-minute meetings in the classroom.

In relation to the implementation of the pilot study, it was possible to observe that the students did not present any difficulties regarding the instructions, and performed the tasks with good understanding.

The reduction of tasks was necessary due to the fact that the students had not yet developed the concepts of solving word problems, multiplication and division, indicating difficulties for the students in carrying out the tests.

The National Common Curricular Base (BNCC) (Brazil, 2015) recommends that students in the 1st and 2nd grade level of Elementary School have developed knowledge of understanding numbers and calculating basic addition and subtraction facts. However, the participants in the pilot study had difficulty performing calculations, making it necessary to reduce the procedure, avoiding that the students were characterized as false positives.

In this way, the application of the screening protocol revealed the necessity to reduce the number of skills. Therefore, the screening protocol was reformulated, now having 5 tests tasks: number sense (magnitude/verbal/arabic transposition); number line, position value, Addition and subtraction. The protocol reformulation was necessary due to the fact that the multiplication, division and problem-solving tasks required more cognitive and learning demands which the students in early school grades don't master.

The study is beneficial to all children who have difficulty in learning mathematics, particularly in developing competence. Bringing the problem to our awareness should be a long-term process and moving forward with environmental changes in education provides a better performance in Mathematical learning.

4. FUTURE GUIDELINES

The Response to Intervention (RTI) Model is a multi-tiered system, divided into 3 levels, with Tier 1 being a universal screening across the classroom responsible for identifying students at risk for mathematical difficulties and referring them to Tier 2 intervention.

Future studies will be conducted to define a reference standard for the population of this study, making this screening protocol usable for the early identification of difficulties in the development of mathematical skills.

More studies are needed to document other important mathematical skills to examine new screenings that are effective for other school levels.

5. CONCLUSION/DISCUSSION

This study sought to develop a screening tool to identify students in early grades at risk for mathematical difficulties using the Response to Intervention (RTI) Model. The development of phase 1, screening, of the study was based on a literature review in databases of schoolchildren in the initial years of literacy, emphasizing basic skills as predictors of later mathematical difficulties.

For Chard et al. (2005), mathematical difficulties are considered to be the efforts of students to recover and use basic mathematical knowledge. For these researchers, the efficiency of an education is due to the prevention of these difficulties through assessment and intervention measures. These measures can be found in the RTI, which is a multi-tiered, three-tiered model that seeks to prevent learning difficulties and monitor the progress of the student from tier 1, screening, identifying students at risk for mathematical difficulties and referring them to tier 2 of intervention.

According to Bryant et al (2008a) the RTI approach validates important Level 2 math interventions by identifying students at risk for math difficulties, as the evidence-based, multi-tiered intervention prevents math difficulties.

Fuchs and Fuchs (2006) considered the necessity of screening tools with reference standards for early evaluation and identification of students at risk for any type of learning difficulties. According to literature (Andrade et al., 2014; Bryant et.al 2016; Fuchs & Fuchs, 2006), two components are important for choosing a screening to identify difficulties: the

ability to measure the students' responsiveness to instruction and the student's non-responsiveness to the stimuli applied in the screening.

The following are considered basic mathematical skills: number sense, number line, place value, addition, subtraction, multiplication, division and problem solving, and these are important predictors of mathematical difficulties presented by students. Therefore, these skills were part of this study based on tasks proposed in tier 1, screening, for possible identification of students at risk in mathematical learning (Bryant et al., 2008a; Bryant et al., 2008b; Fuchs et al., 2007a; Fuchs et al., 2007b; Geary, et.al. 2009; Jordan et al., 2007)

However, with the application of tier 1 in the pilot study, it was observed that students in the initial phase of literacy in mathematics had not yet mastered the skills of multiplication, division and problem solving, thus requiring their removal from the screening protocol.

In 2005, from a total of 564 first grade students, Fuchs, et.al. (2005) identified 127 students at risk for mathematical difficulties from tier 1, that is, from screening. After identifying the students at risk, they received tier 2 intervention and demonstrated significantly better performance in mathematical learning.

The importance of the screenings is to identify safely, quickly and at a low cost which skills measure the students' performance identifying the risk of learning difficulties, more specifically in this study, the difficulties in developing mathematical skills.

Thus, the results of this study showed that the need for adjustments to the screening protocol for the mathematical difficulties elaborated in this study, based on the results of the pilot study, made the protocol more robust for investigating the mastery of basic knowledge related to addition, subtraction and, thus, capable of identifying students at risk for mathematical learning in early school grades.

The results of these studies allowed us to conclude that it was possible to develop a screening protocol through the Response to Intervention Model (RTI) based on bibliographical research considering the main mathematical skills to identify students in the early school grades at risk of mathematical difficulties, by the way, the need for adjustments to the screening protocol for the mathematical difficulties, based on the results of the pilot study.

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Chapter # 40

ACTIVE LEARNING METHODS IN ANATOMY TEACHING FOR OPERATING ROOM NURSING

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ABSTRACT

Several studies have shown the benefit of drawing when learning anatomy. Virtual Reality (VR) also appears to be useful when learning about anatomical structures. This study aimed to describe how students in a master study programme in operating room (OR) nursing perceived the combination of drawing and the use of VR in the learning of anatomy. Constructivism and a sociocultural view of learning constitute a foundation for applying these active learning methods. The two methods were combined in a class of 29 students. The students were provided half-finished drawings of anatomical structures that they were to complete with guidance from the teacher. They also were to find various anatomical structures by using VR technology. A paper questionnaire was applied to evaluate the teaching programme. Data were analysed statistically (check-off questions) and descriptively (open-ended questions and comments field). Twenty-eight students (96.6%) completed the questionnaire. The students highly appreciated both learning methods. They reported that drawing made them work more actively during lectures and increased learning outcomes. They also perceived that the use of VR technology increased their understanding of the location of anatomical structures. The combination of drawing and VR technology appears to offer significant benefits to OR nursing students when learning anatomy, by both increasing student engagement and enhancing their understanding of anatomical structures.

Keywords: operating room nursing, anatomy education, immersive virtual reality, learning by drawing.

1. INTRODUCTION

An operating room (OR) nurse has an independent responsibility for the patient in surgery. When the patient is positioned for surgery, knowledge and skills related to anatomy are essential. For the patient to be optimally exposed during surgery, the patient may be positioned in many different and sometimes unnatural body positions. To be able to do this safely, the OR nurse must be familiar with anatomical structures and how they work (Devlin & Nanavati, 2023). Devlin and Nanavati (2023) claim that, for positioning the patient, OR nurses need to know the cardiovascular system, respiratory system, skin and underlying tissue, musculoskeletal system, and nervous system.

An OR nurse works as part of the surgical team. When assisting in the sterile field, the OR nurse needs knowledge about the various organs, where they are located, and how to treat them. Different instruments and equipment are used on the different organs, and incorrect use of instruments can damage the organs (Rothrock, McEwen, & Van Wicklin, 2023). Thus, knowing anatomy is crucial for students who want to become OR nurses, as it involves positioning the patient correctly for surgery and assisting during operations.

Master's students in OR nursing have a bachelor's degree in nursing before starting the programme. This means they have basic knowledge of anatomy. However, the curriculum of the OR nursing programme states that students should have in-depth knowledge of the anatomy of organ systems and be able to apply this knowledge when the patient is being treated. This understanding must be demonstrated both as learning outcomes and in practical skills within the surgical team (Western Norway University of Applied Sciences, 2024).

2. BACKGROUND

Learning anatomy and other bioscience subjects can be challenging (McVicar, Andrew, & Kemble, 2015), and it has been argued that the use of traditional passive and teacher-centred learning approaches could be one of the reasons for this (Thwin, 2017). Although students learn in various ways, many students seem to prefer active and varied learning methods rather than traditional lectures when studying anatomy and other bioscience subjects (Johnston et al., 2015; Joseph, Roach, Natarajan, Karkada, & Cayaban, 2021).

The term 'active learning' may be understood in different ways. Freeman et al. (2014) collected written definitions of active learning from 338 participants in a seminar on active learning. After coding of the elements that emerged in the definitions, a consensus definition was formulated. The main elements in this definition are that active learning involves learning through classroom activities and discussions, and group work is often part of the active learning process. The importance of emphasising higher order thinking is also highlighted in their definition (Freeman et al., 2014).

Learning through discussion and group work and applying higher order thinking aligns with social constructivism, as described by Vygotsky (Botha, 2020). This implies that new understanding is achieved by connecting new information with previously acquired knowledge, and that interpersonal interaction is perceived as central to the learning process. Student participation, collaboration and discussion are central elements in the classroom (Prakash Chand, 2023). Constructivism and a sociocultural view of learning therefore constitute a theoretical foundation for the application of active learning methods.

A combination of various active learning methods seems to be beneficial in the learning of anatomy (Sørø, Aglen, & Haugan, 2021). Thwin et al. suggested various approaches for achieving effective and efficient anatomy teaching. This includes the use of active learning strategies both during lectures and in small group teaching (Thwin, 2017) in accordance with the definition formulated by Freeman et al (2014).

One of the learning methods suggested is colouring diagrams in workbooks (Thwin, 2017). Several studies have shown the benefit of drawing when learning anatomy. It has been argued that drawing may support students' understanding and visualisation of anatomical structures and thus facilitate their knowledge retention (Adkins, Barrett, D'Amato, Maxwell, & Kindig, 2023; Borrelli, Leung, Morgan, Saxena, & Hunter, 2018). It has also been proposed that drawing may have an impact on a memory trace by combining elaborative, motoric and pictorial elements (Fernandes, Wammes, & Meade, 2018). Students' drawing skills are probably not essential for their learning, as the aim is to draw anatomical key points rather than to create perfect drawings of anatomical structures (Borrelli et al., 2018).

Drawing as a pedagogical tool may be used in different ways. Noorafshan et al. (2014) applied an interactive model where students were to draw simple anatomical sketches simultaneously with the teacher. This made the students participate more actively during lectures, and most of them found that this facilitated their learning of anatomy. In a study regarding obstetric and gynaecological clerkship sessions for medical students, the students were required to draw anatomical structures and subsequently explain their drawings for

fellow students. Most of the students found this interactive session helpful for their understanding of anatomical structures (Adkins et al., 2023).

Virtual Reality (VR) technology is another learning method that has gained significant attention in higher education and training across various disciplines in recent years. It allows the user to explore and manipulate computer-generated real or artificial three-dimensional multimedia sensory environments in real time (Kyaw et al., 2019). *Immersive virtual reality* (IVR) creates an environment that surrounds viewers, enhancing their sense of presence. By adopting a first-person perspective, users can interact with the virtual environment in real time, resulting in a heightened and realistic experience (Slater & Sanchez-Vives, 2016).

Several systematic reviews have consistently demonstrated that students who engage with VR achieve higher learning outcomes and retain information better compared to control groups using different media (Di Natale, Repetto, Riva, & Villani, 2020; Kyaw et al., 2019; Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020). Di Natale et al. (2020), in their systematic review, looked at the use of IVR in higher education through the lens of Dalgarno and Lee's (2009) framework of affordances for 3D virtual learning environments. They suggested that these affordances (characteristics that enable certain types of learning behaviour) may also be applied to IVR. These affordances are:

1. Spatial knowledge – IVR provides spatial knowledge representation and, therefore, allows for a better understanding of spatial relationships.
2. Experiential learning – IVR allows students to perform tasks that would be impossible or impractical to perform in the real world.
3. Intrinsic motivation and engagement – IVR improves the motivational appeal of instructional material, promoting increased student interest and perceived learning outcomes.
4. Transfer of knowledge – IVR improves the transfer of knowledge by supporting situated learning.

(Dalgarno & Lee, 2009; Di Natale et al., 2020).

Like drawing, interacting with a 3D model in VR includes motoric elements as the students use hand controls. By physically engaging and interacting with the learning materials through body movements, students activate sensorimotor areas within their brain, and it has been hypothesized that this promotes both faster and deeper learning (Johnson-Glenberg, 2018).

When it comes to the learning of anatomy, a study among nursing students showed that a VR-based programme significantly improved students' learning of anatomy compared to traditional learning methods (Wang et al., 2023). A systematic review, a meta-analysis covering 15 studies regarding the effectiveness of VR, also concluded that VR can potentially improve the teaching of anatomy. However, there was some uncertainty about the results, partly due to the heterogeneity of the studies, and further research on how VR can be integrated into the teaching of anatomy was encouraged (Zhao, Xu, Jiang, & Ding, 2020).

In the present study, we combined drawing and VR in the anatomy teaching for OR nursing. The aim of this study was to describe how students in a master study programme in OR nursing perceived the benefit of the combination of two active learning methods – drawing and the use of VR – in the learning of anatomy. To our knowledge, this is the first article describing the combination of these two learning methods in the learning of anatomy in health education.

3. METHODS

3.1. Design and Participants

This pilot study had a cross-sectional design. The manuscript was drafted against the SQUIRE-EDU (Standards for Quality Improvement Reporting Excellence in Education): Publication Guidelines for Educational Improvement (Ogrinc, Armstrong, Dolansky, Singh, & Davies, 2019).

We developed a new teaching programme in anatomy for students in the master study programme in OR nursing at a university college by combining learning by drawing and using VR technology. The sample chosen for this study was a class of students in the master's programme in OR nursing that started their master's education in autumn 2023. All the students in the class participated in the teaching programme, and all were invited to participate in the evaluation of the programme by completing a questionnaire. Altogether, 29 students, spread across three different campuses, participated in the programme, and 28 of them participated in the evaluation. The new teaching programme consisted of:

1. A gathering at one of the campuses with:
 - A two-hour session of interactive lectures where students had to draw and name various anatomical structures, guided by the teacher.
 - A two-hour session where students were to find different anatomical structures using VR sets and '3D Organon' – a VR application about human anatomy.
 - Demonstration of positioning of patients on the operating table.
2. Three two-hour sessions with the drawing of anatomical structures, guided by the teacher. These sessions were conducted in person at one of the campuses with digital transmission to students at the two other campuses. Students on these campuses were able to communicate with the teacher via microphones in the classrooms.

For the drawing lessons, the students were provided two drawing pads, covering topics from the respiratory system, circulatory system, nervous system, musculoskeletal system, organs in the abdomen and organs in the pelvis. Thirty-eight of the drawings were half-finished drawings that the teacher had made of various anatomical structures. The drawing pads were made available to the students electronically, so they could print them out and bring them to class. During the lessons, the students had to complete the half-finished drawings by drawing in different anatomical structures and adding names to the drawings while being guided by the teacher. Simultaneously, the teacher showed the same drawings on a screen in the classroom using a document camera and drew and wrote together with the students. When the students participated digitally from other campuses, what was shown on the screen was also transmitted digitally. Drawing and naming of anatomical structures were done in dialogue with the students, as they were encouraged to suggest names to be written on the drawings, for example.

For the VR session, we applied the Pico Neo3 model of portable and cableless head mounted display (HMD) devices. These VR sets consist of "goggles" that cover the entire field of view of the user and provide stereoscopic vision and a sense of depth, and two controllers held in hands that help navigate the virtual environment and interact with the objects in it. Portable HMD devices offer the benefit of providing fully immersive VR.

3D Organon, the application we used, enabled students to engage with 3D models of various human anatomy systems. Through 3D Organon, students could examine the systems both together and individually, navigate around the models and turn them along both horizontal and vertical axes. They could also magnify the model, disassemble it and explore its components individually.

The topics chosen for the VR session were skeleton, muscles, arteries, and nerves in the upper and lower limbs. These were also the topics of the preceding teaching with drawing on the same day. The subsequent demonstration on the operating table also focused on how patients must be positioned to prevent damage to the anatomical structures in the upper and lower limbs.

At the beginning of the VR session, we gave short instructions on the use of the software-relevant buttons. We also provided written instruction regarding the anatomical structures the students were to find and what 3D models in the anatomy programme they had to explore to find these structures.

During the two-hour VR session, students worked in small groups, two or three students together. One of the students in each group wore HMD. What was shown in VR was transmitted to a PC screen, and in that way, it was made available for the other student(s) in the group. The students took turns wearing HMDs and looking at the computer screen, and so everyone was able to explore the 3D models and anatomical structures in VR. This also meant that each student did not have to wear HMD all the time. This may be an advantage, as dizziness and other discomfort symptoms are reported when using HMDs (Oh & Son, 2022; Wang et al., 2023).

The students evaluated the teaching programme using a paper questionnaire, which was made by the teachers. It consisted of 17 check-off questions and five open-ended questions, including one field where they could write other comments. Two of the check-off questions were about whether the students attended the gathering at one of the campuses and how many of the subsequent teaching sessions they participated in. The rest of the questionnaire consisted of two panels of questions, one for the drawing part and one for the VR part. Six of the check-off questions in the drawing part and five of the check-off questions in the VR part were scored on a 5-point scale from 1: totally agree to 5: totally disagree. A sum score was calculated for these questions in each of the two parts. Lower scores indicated better use. The questionnaire and students' responses were written in Norwegian; translations to English are by the authors.

3.2. Statistical Methods

Descriptive statistical analysis was performed for ordinal variables using frequencies and percentages. To test positive relationship between two ordinal variables, we used the chi-squared test for linear-by-linear association with exact one-sided p-value. Cronbach's alpha was estimated to quantify internal consistency of the drawing and VR scale, respectively. All the data from the evaluation forms were analysed in SPSS.

3.3. Analysis of Open-Ended Questions and Comments Field

The total word count of comments (quotes) provided in the comments field and as answers to open-ended questions was small at approximately 800. Therefore, we chose to analyse the comments descriptively by using some elements from summative content analysis (Hsieh & Shannon, 2005). We read through the comments searching for occurrences of central words (e.g., 'organs' and 'nerves'). These words formed the basis for various categories of meaning. Each comment (quote) represented a meaning unit (or sometimes several meaning units). The meaning units were sorted into the different categories. In doing

this, we included words with similar meanings. As an example, the comment “More heart and lung anatomy” was sorted in the category ‘Thoracic and/or abdominal organs’, although this comment did not contain the word ‘organ’ (Table 1). We then summarised the number of comments with similar meanings as inspired by summative content analysis (Hsieh & Shannon, 2005).

Table 1.

Example of the sorting of comments (meaning units). The table shows the categorisation of some of the comments regarding what topics the respondents would have liked to include in the virtual reality (VR) exercise other than the topics chosen.

Comment (quote)	Category
Would rather have organs in the abdomen	Thoracic and/or abdominal organs
Abdominal organs	
Abdominal organs, digestive organs	
More heart and lung anatomy	
Abdominal and thoracic organs	
Other organs and structures	Unspecified organs
Larger organs	
Also the larger organs	
Internal organs	
All organ systems	

3.4. Ethical Considerations

Written information was provided on the questionnaire that participation in the evaluation was voluntary and that names should not be written on the evaluation form. Subsequently, we also contacted the Norwegian Agency for Shared Services in Education and Research (SIKT) to assess whether the project was notifiable to them. Their assessment was that if the submitted questionnaires did not contain information that could enable a person who did not know the participants to identify individuals, the project was not notifiable. Information that could identify individuals among the participants did not appear in the submitted questionnaires.

4. RESULTS

Twenty-eight out of the 29 students (96.6%) completed the questionnaire used to evaluate the teaching programme. All 28 respondents had participated in person at the gathering at one of the campuses. 27 respondents participated in all three of the subsequent 2-hour sessions (either in person or digitally), while one respondent had participated in two of these sessions.

Sixteen of the respondents (57.1%) thought the distribution of 2 hours of exercise with VR and 8 hours of lessons with drawing was appropriate. Six respondents (21.4%) preferred to have more VR exercise and less teaching with drawing, while five respondents (17.9%) preferred to have less VR exercise and more teaching with drawing. Some respondents also commented that they would have liked to have more of both.

The students were asked to indicate the extent to which they agreed or disagreed with various statements regarding the interactive lectures with drawing. These results are shown in Table 2.

Table 2.

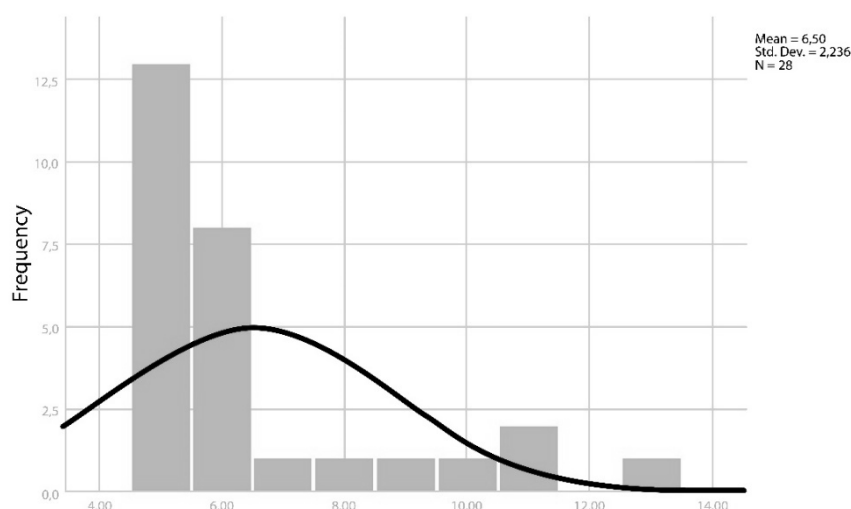
The extent to which 28 respondents disagreed/agreed with six statements related to the use of drawing in the teaching of anatomy in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statement	Extent to which the respondents agree, n (%)					Total
	Totally agree	Partly agree	Not sure	Partly disagree	Totally disagree	
The drawing pads made me more active in class	27 (96.4)	1 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)	28 (100)
The drawing pads made it easier to understand the subject matter	25 (89.3)	3 (10.7)	0 (0.0)	0 (0.0)	0 (0.0)	28 (100)
The use of drawing pads increased learning outcomes in lessons	27 (96.4)	1 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)	28 (100)
I would have preferred to use PowerPoint rather than drawing in the lessons	2 (7.1)	1 (3.6)	1 (3.6)	3 (10.7)	21 (75.0)	28 (100)
I have also benefitted from the drawing pads when I have worked on subject matter outside of class	23 (82.1)	1 (3.6)	2 (7.1)	2 (7.1)	0 (0.0)	28 (100)
The drawing pads have contributed to me also using drawing myself in my work with the subject matter outside of class	15 (53.3)	7 (25.0)	0 (0.0)	5 (17.9)	1 (3.6)	28 (100)

The mean sum score for the drawing part (all six items shown in Table 2) was 8.1 and Cronbach's alpha was 0.47. The statement comparing drawing with PowerPoint had a very low correlation with the total scale, and after this was removed from the scale, the mean was 6.5 (Figure 1) and Cronbach's alpha increased to 0.59.

Figure 1.

Sum score (x-axis) of five statements regarding the use of drawing, each ranked from 1: totally agree to 5: totally disagree (thus, the possible range for the sum score is 5–25, where 5 represents answering ‘totally agree’ with all five statements, and 25 represents answering ‘totally disagree’ with all five statements). Frequency (y-axis) shows the number of respondents represented in each column. Vertex of graph (curved line) shows the mean score (6.5) for respondents that scored all five statements (28 respondents).



When we used the linear-by-linear chi-squared test, there was no significant relation between the students’ experience of teaching with drawing and the fact that they themselves used drawing to work with the subject matter (Table 3).

Table 3.

Associations between students’ opinion on the drawing sessions and their use of drawing when working with the subject matter themselves ($n = 28$) in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statement	p-value ^{a)}
The drawing pads made me more active in class	0.214
The drawing pads made it easier to understand the subject matter	0.370
The use of drawing pads increased learning outcomes in lessons	0.214
I would have preferred to use PowerPoint rather than drawing in the lessons	0.464

a) Exact 1-sided p-value from chi-squared test for linear-by-linear positive association between ordinal variables with 5 levels

The students were also asked to indicate the extent to which they agreed or disagreed with various statements regarding the exercise in VR. These results are shown in Table 4. For the VR part, the mean sum score for all five items shown in Table 4 was 8.7 (Figure 2), and Cronbach’s alpha was estimated to be 0.86.

Table 4.

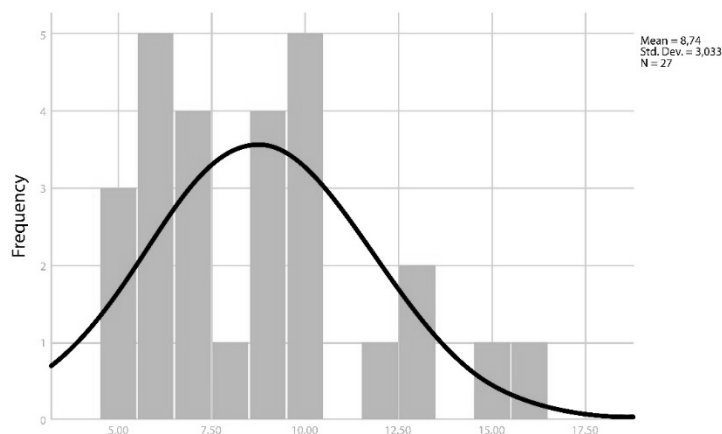
The extent to which 28^{a)} respondents disagreed/agreed with five statements related to the use of VR in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statement	Extent to which the respondents agree, n (%)					Total
	Totally agree	Partly agree	Not sure ^{b)}	Partly disagree	Totally disagree	
It was easy to use the anatomy programme used in the exercise with VR	9 (32.1)	14 (50.0)	3 (10.7)	2 (7.1)	0 (0.0)	28 (100)
It was easy to find the anatomical structures we were to find on the models	6 (21.4)	15 (53.6)	5 (17.9)	2 (7.1)	0 (0.0)	28 (100)
The use of VR made it easier to understand the subject matter	14 (50.0)	10 (35.7)	4 (14.3)	0 (0.0)	0 (0.0)	28 (100)
The use of VR gave me a better understanding of the location of anatomical structures	20 (71.4)	7 (25.0)	1 (3.6)	0 (0.0)	0 (0.0)	28 (100)
The use of VR provided a great learning outcome	11 (40.7)	12 (44.4)	4 (14.8)	0 (0.0)	0 (0.0)	27 (100)

a) 27 respondents on the fifth statement; b) For the first two statements, the category in this column was the Norwegian expression 'både/og' which means something in between 'agree' and 'disagree'

Figure 2.

Sum score (x-axis) of five statements regarding the use of VR, each ranked from 1: totally agree to 5: totally disagree (thus, the possible range for the sum score is 5–25, where 5 represents answering 'totally agree' with all five statements, and 25 represents answering 'totally disagree' with all five statements). Frequency (y-axis) shows the number of respondents represented in each column. The vertex of the graph (curved line) shows the mean score (8.7) for respondents that scored all five statements (27 respondents).



When it comes to the respondents' previous experience with VR, 23 of the 28 respondents had no previous experience, four participants had tried VR 1 or 2 times before, and one respondent 3 to 5 times before. Previous use of VR may have given a slight advantage when students were to find anatomical structures on the 3D models, but numbers are small, and this finding is statistically uncertain ($p = 0.045$). Previous experience with VR did not significantly affect students' ability to use the anatomy programme itself, their understanding of the subject matter or their learning outcome when using VR (Table 5).

Table 5.

Associations between the students' previous experience with VR and their ability to use the anatomy programme and their perceived benefit of using VR in 28^{a)} respondents in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statements regarding the use of and the benefit of VR in the learning of anatomy	p-value ^{b)}
It was easy to use the anatomy programme used in the exercise with VR	0.191
It was easy to find the anatomical structures we were to find on the models	0.045
The use of VR made it easier to understand the subject matter	0.199
The use of VR gave me a better understanding of the location of anatomical structures	0.138
The use of VR provided a great learning outcome	0.053

Abbreviation: VR = Virtual Reality

a) 27 respondents in the fifth statement; b) Exact 1-sided p-value from chi-squared test for linear-by-linear positive association between ordinal variables with 5 levels

We also investigated how students' responses to questions regarding the learning outcome and improved understanding related to how they managed to use the anatomy programme in VR (Table 6). As the table shows, there was a significant positive association between students' perceived learning outcome and how they managed to use the programme and find anatomical structures. Students who largely perceived that the anatomy programme was easy to use and the anatomical structures were easy to find, also reported to a greater extent that the use of VR made it easier to understand the subject matter. This was statistically significant, as shown in the table. However, as the table shows, there was no significant association between students' improved understanding of the location of anatomical structures and their perceived ability to use the anatomy programme or to find anatomical structures on the models.

Table 6.

Associations between the students' learning outcome and improved understanding and how they managed to use the anatomy programme and find the different anatomical structures in 28 respondents in the master study programme in operating room nursing at a university college in Norway, autumn semester of 2023.

Statements regarding the learning outcome and improved understanding	Statements regarding the use of the anatomy programme	p-value ^{a)}
The use of VR made it easier to understand the subject matter	It was easy to find the anatomical structures we were to find on the models	0.003
The use of VR made it easier to understand the subject matter	It was easy to use the anatomy programme used in the exercise with VR	0.020
The use of VR gave me a better understanding of the location of anatomical structures	It was easy to find the anatomical structures we were to find on the models	0.074
The use of VR gave me a better understanding of the location of anatomical structures	It was easy to use the anatomy programme used in the exercise with VR	0.053
The use of VR provided a great learning outcome	It was easy to find the anatomical structures we were to find on the models	0.001
The use of VR provided a great learning outcome	It was easy to use the anatomy programme used in the exercise with VR	0.005

Abbreviation: VR = Virtual Reality

a) Exact 1-sided p-value from chi-square test for linear-by-linear positive association between ordinal variables with 5 levels

Twenty-six of the respondents provided at least one text comment in the questionnaire. When it comes to the text comments regarding the drawing lessons, 17 of the students expressed in different ways that they appreciated this learning method. Six of these explicitly expressed that they learned a lot, and three highlighted the active learning. Two of the respondents specifically expressed the advantage of this form of teaching over PowerPoint. Two respondents expressed that the drawing pads could have been better organised, and one student recommended using PowerPoint in addition to drawing to show anatomical figures. This student also mentioned that, in retrospect, the VR teaching provided a more comprehensive understanding of anatomy that might otherwise have been lacking.

When it comes to the open-ended questions regarding the VR exercise, the students were asked whether topics should have been added or omitted in this exercise. Seventeen students expressed in different ways that they would have liked to include other topics. Of these, seven mentioned organs in the abdomen and/or thorax. In addition, eight respondents mentioned organs without specifying name or exact location. (Examples are shown in table 1). However, several of these provided answers such as 'internal organs' or 'larger organs', probably also indicating thoracic or abdominal organs. Five respondents mentioned the nerves as something that could have been omitted from the exercise, and it was commented

that these were difficult to grasp in VR due to their small size. Five respondents answered explicitly 'no' to the question of whether some topics could have been omitted.

When it comes to comments regarding the teaching programme as a whole, six respondents expressed a lack of time in various ways. This was related to the size of the course, the time given to prepare for the exam or the schedule of the gathering at one of the campuses.

5. DISCUSSION

The aim of the study was to describe how students in a master study programme in OR nursing perceived the benefit of active learning methods, including drawing and the use of VR technology.

The results show that a great majority of the students appreciated the use of both learning methods. This is supported by the sum score for the drawing part and the VR part of the questionnaire, respectively, and by the analysis of responses to open-ended questions and comments field in the questionnaire. The combination of drawing and VR in learning, is, as far as we have found, scarcely studied. In art education, combining VR and painting has been used (Guan, Wang, Wang, Zhu, & Hwang, 2024), but we have not found any research articles describing the combination of drawing and VR in health education. Nevertheless, combining various approaches to active learning is recommended in anatomy teaching (Sørø et al., 2021; Thwin, 2017).

At the gathering at one of the campuses, we focused on anatomical structures in the upper and lower limbs both in the drawing lessons, the VR exercise, and the demonstration of positioning the patient on the operating table. In this way, the learning was integrated by allowing the students to encounter the same topic in three different arenas, the last of which was close to practice. The combination of various active approaches and integrating them in nursing have proved to be successful factors when teaching anatomy to bachelor nursing students (Sørø et al., 2021). This aligns with social constructivism, where student participation and collaboration are central in the learning process (Prakash Chand, 2023). It seems likely that this combination may also be a useful approach when teaching anatomy for OR nursing students, as these students need even deeper knowledge in anatomy for several reasons (Devlin & Nanavati, 2023; Rothrock et al., 2023). This is also in line with what one of our respondents expressed, which was that VR in addition to drawing provided a more comprehensive understanding than drawing alone.

When it comes to drawing, the benefit of this learning method in anatomy is also supported by other studies (Adkins et al., 2023; Borrelli et al., 2018; Noorafshan et al., 2014). When respondents in our study clearly reported that the drawing pads made them more active in class, it is in accordance with the definition of active learning given by Freeman et al., wherein activities and discussion in class are emphasised (Freeman et al., 2014). The students also reported that drawing made it easier to understand the subject matter and improved their learning outcome, similarly to what Noorafshan et al. (2014) found in their study. One reason for this may be that the activity of drawing forces students to pay attention to what they are doing, as they have to concentrate on what they draw, and thus cannot be passive listeners (Ainsworth & Scheiter, 2021). In addition to the effect of the activity itself, the pace of the teaching may have contributed to improved learning outcomes. When drawing together with the students, the teacher is forced to slow down, as drawing takes time. This means that the amount of information the students must deal with during a lecture is reduced, which can prevent cognitive overload. This may contribute to facilitating knowledge retention, as argued by Borrelli et al. (2018) and Adkins et al. (2023).

Most of the respondents benefitted from the drawing pads outside of organised teaching, and for many of them, the pads also contributed to them using drawing when working with the subject outside of class. However, we did not find statistical correlations between the students' opinion on the drawing lessons and their use of drawing outside of class. The size of the data material and the small spread in the students' responses may be contributing factors to this, making it difficult to obtain statistical significance. However, students' different learning styles may also be a reason (learning-styles-online.com, n.d.). It is possible that whether students choose drawing as a learning method when working on their own depends more on their learning style than the use of drawing during lectures.

When it comes to VR, most of the respondents totally or partially agreed that the use of this learning method provided a great learning outcome and better understanding. This is in accordance with previous research that shows that VR has a generally positive effect on students' learning outcomes when compared to other teaching methods (Di Natale et al., 2020; García-Robles et al., 2024; Kyaw et al., 2019; Radianti et al., 2020). In the background section of the article, we mentioned the theory of affordances given by Dalgarno and Lee (2009), which was applied to VR by Di Natale et al. (2020). Our results indicate that at least the first three of these affordances may have contributed to the respondents' great perceived learning outcome and improved understanding of the subject matter in our project.

Our results also indicate that the students' previous experience of using VR did not seem to have a large impact on their ability to use the anatomy programme or on their perceived benefit of using VR. One possible explanation may be that using VR equipment combined with the 3D Organon application is sufficiently intuitive to make it equally easy to use both for individuals already familiar with the technology and for those completely new to it. This is in accordance with an integrative review that revealed that users' experiences with various kinds of VR technologies were mostly positive, although a few VR systems were difficult to use (Mäkinen, Haavisto, Havola, & Koivisto, 2020). On the other hand, previous experiences from using HMDs and the same anatomy programme as we used in our project showed that students' and teachers' experience with the technology is of importance (Aasekjær, Gjesdal, Rosenberg, & Bovim, 2023).

Another explanation as to why students' previous experience of using VR did not seem to be having a large impact may be that the short instructions on the use of the software-relevant buttons that we gave at the beginning of the VR session combined with the written instructions provided regarding the anatomical structures they were to find played a significant role for first-time users in familiarising them with the technology and the use of the anatomy programme. Lack of instruction may cause uncertainty when students use VR in learning (Aasekjær et al., 2023). An additional comparative study could provide insights into whether the implementation of a deliberately designed introduction plays a role in bridging the gap between first-time users and experienced individuals.

The respondents were a bit divided regarding their opinions on the use of the programme itself and about finding the anatomical structures on the 3D models. The perceived learning outcome and understanding of the subject matter correlated to how easy the students perceived finding the anatomical structures. Although not significant, earlier experience with VR seemed to give a slight advantage when students were to find anatomical structures, in accordance with previous experiences showing that it is of importance that students are familiar with the VR technology (Aasekjær et al., 2023). As mentioned above, for the VR exercise, we chose anatomical structures in the limbs to link this exercise to the preceding drawing lesson and the subsequent demonstration on the operating table the same day. This also meant that the students had to find various nerves in the limbs. As several of the respondents commented, nerves are small and can be difficult to grasp in VR. Many

students also expressed that they would have preferred to explore organs in the thorax and abdomen during the VR exercise. As these organs are larger, they are easier to find in the anatomy programme. In retrospect, we see that we could have chosen larger organs and focused only on the nerves most vulnerable to pressure injury during operations.

Although the students appreciated the use of active learning methods, there are challenges associated with this kind of learning. These challenges include, amongst other things, engaging students, building students' relations and developing teaching strategies that promote learning (Aga, 2023). A literature review revealed that time constraints may be a major challenge for students (Rahman, Sahid, & Mohamad Nasri, 2022). This was also a challenge in our study, as several students in various ways commented on not having enough time. The lack of time may in turn lead to cognitive overload, which may reduce students' motivation (Takase, Niitani, Imai, & Okada, 2019). As teachers we therefore must ask ourselves what is most important to prioritise in various kinds of active learning sessions. It also is important that the curriculum is organised in a way that gives students time to work sufficiently on the subjects outside of organised learning activities. To address this challenge, it may be necessary to take a more overarching view of the curriculum and how the teaching is organised (Novais, Silva, & Muniz Jr., 2017).

6. STRENGTHS AND LIMITATIONS

One limitation is the size of the study, as only 29 students attended the master study programme in OR nursing. However, the response rate was high (96.4%), indicating that the answers are representative for the opinions of the students attending.

Another limitation is that the questionnaire was not validated. For this study, we used a self-made questionnaire. The estimated internal consistency for the check-off questions regarding the use of drawing was lower than 0.70, thereby limiting the generalisation of the answers to these questions. The estimated internal consistency for the check-off questions regarding the use of VR, however, was higher than 0.70 (0.86).

A limitation in the performing of the statistical analysis is that the respondents provided rather similar answers to several of the check-off questions in the questionnaire. This made it more difficult to calculate the statistical correlations between the different statements that the students had to consider.

Having a control group would also have been an advantage for comparing the effect of the teaching programme investigated.

7. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The combination of drawing and VR technology appears to offer significant benefits to OR nursing students learning anatomy, by both increasing student engagement and enhancing their understanding of anatomical structures. The students in this study reported a high level of appreciation for the anatomy lectures, where they were guided in completing drawings, as well as for the VR session that allowed them to explore 3D models of anatomical structures. The majority of respondents indicated that drawing actively engaged them during lectures and contributed to better learning outcomes. Similarly, most students found the VR sessions helpful in improving their understanding of the spatial relationships between anatomical structures.

However, while students' perceived learning outcomes from the VR session were positively related to how effectively they could use the VR programme, it is important to note that a lack of previous experience with VR had little or no impact on the perceived

benefits of the use of the technology. This suggests that the threshold for integrating VR into anatomy education is relatively low, making it accessible to students with varying levels of technological familiarity.

Despite the promising results, there are areas that could benefit from further investigation. For instance, including larger groups of students or those from different educational backgrounds, to explore whether the combination of drawing and VR is equally effective across different cohorts. Dividing students into a control group and a test group could also improve the credibility of the results. Additionally, investigating the impact of these methods on student performance in practical settings, such as clinical placements or surgical simulations, would be interesting to assess whether the improvements in spatial understanding translate into better practical skills.

Finally, future research could examine the potential of integrating other emerging technologies, such as augmented reality (AR) or interactive digital platforms, to further enhance anatomy education. Additionally, comparing the effectiveness of the combined methods to traditional teaching approaches could provide more insight into their relative benefits and limitations.

In summary, this study highlights the potential of combining drawing and VR to enhance anatomy learning for OR nursing students. Future investigations should focus on refining these methods, exploring their long-time impact, and expanding their application to other areas of health education to determine their broader utility.

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Section 4

Organizational Issues

Chapter # 41

FACILIS DESCENSUS AVERNO

Or Effects of Interactions Between Own PhD Research Project and Other Projects Initiated within University

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ABSTRACT

This chapter is focused on PhD research projects in a large university, aiming to analyse the effects of their interactions with other organizational projects of the university. Assuming that objectives of doctoral research projects are aligned to the strategic objectives of the university, there were a few research questions, specific to this explorative study: How could the effects of interactions be measured? Are the effects of interactions always positive? If the effects of interactions are negative, then which might be the reasons behind them? Ultimately, are there any solutions to avoid or mitigate the negatives? The study includes both secondary research (literature survey) and primary research: directly observed and personally experienced doctoral projects in a Romanian university environment under scrutiny, completed with semi-structured interviews with doctoral students. This piece of work reveals novel types of inter-project conflicts within higher education institutions, and findings allow the formulation of several recommendations, which are critically important to doctoral schools and PhD supervisors as well as to major stakeholders: higher education leaders and strategists, policy and decision makers, administrators and research managers. Alignment of objectives is essential.

Keywords: project interactions, doctoral research projects, organization *versus* project, organization management *versus* project management, higher education and research.

1. INTRODUCTION

1.1. Explaining the Title

The old Latin dictum *facilis descensus Averno*¹ (attributed to the Roman poet Publius Vergilius Maro), which has circulated in the Christian era as *the road to hell is paved with good intentions*, has the same meaning in English (Collis & Risso, 1992; Kruger & Gilovich, 2004; Kalman, 2010) as well as in many other languages (Ray, 1768; Mawr, 1885; Scarlat, 2019).

Its profound meaning (in terms of how the wonder-plans may turn into not-so-wonderful reality) is explained by scholars (Powers, Koestner, & Topciu, 2005; Gollwitzer & Sheeran, 2006) using the modern instruments of social psychology. Scarlat (2019, pp. 179–202) also provided evidence of proverbs that illustrate such behaviours along project life cycle or abstract principles of project management (Scarlat, 2022).

1.2. How the Road to Hell can be Paved with Good Intentions: UBI Experiment

A large-scale experiment (i.e. research project) targeting poverty alleviation, conducted in the USA between 2019 and 2023 in two states (Illinois and Texas) is an excellent illustration of the old dictum.

The results of the largest American controlled experiment in Universal Basic Income (UBI) were reported in July 2024 (Vivalt, Rhodes, Bartik, Broockman, & Miller, 2024). Over 40,000 volunteers, filtered after eligibility screening and randomization, were finally split into two groups: 1,000 treatment group and 2,000 control group. Different amounts of money were distributed monthly to the members of treatments group (\$1,000 as compared to \$50 to members of control group) – so that a person in the treatment group received in average \$34,200 for the duration of experiment. As reported, the UBI experiment had some “surprising and potentially troubling” results.

The findings suggest that while participants received a “financial boost”, it didn't translate into improved economic outcomes (Vivalt et al., 2024, pp. 30–31): “Even a fully unconditional cash transfer results in moderate labor supply reductions for recipients” and “rather than being driven by such program features, participants [in the study] reduced their labor supply because they placed a high value, at the margin, on additional leisure”. Despite receiving an additional \$12,000 annually through UBI,

- Participants ended up earning less overall (*household income decreased by 21 cents for every dollar of UBI received*).
- There was a noticeable *increase in unemployment duration* among UBI recipients, and they worked less compared to those in the control group.
- There was an increase in self-reported disability among participants, potentially indicating *a decline in their willingness or ability to work*.

This example is an excellent illustration of how best intentions can end up with negative outcomes. *An apparently good idea does not always work in practice*. Nevertheless, this experiment has paid off because, in the absence of this experiment, the consequences of enforcing such failing act at country-scale would have been disastrous!

2. BACKGROUND: ACADEMIC WORLD MULTIFOLD CHALLENGED

Currently, the international tense context has direct consequences on international trade of goods, services, and technology transfer, which, at their turn, are influencing the investment flows going to research and development (academic scientific research included). Consequently, the academic research (and universities in general) experience “chronic disruption and crises” (Ling & Livingston, 2024) as effect of the tense international relationships between the global powers because of their efforts for supremacy as well as associated complex processes.

Scientific research is under double international pressure: technology advance competition as well as commercial applications that require shorter time-to-market. If top-technology advance involves years and even decade-long time to catch up (Economist, 2020), which is a serious limitation for most countries, the market pressure is everywhere; it leads to risky decisions in terms of unfinished or superficial market-tests. In other words, as proverb goes, *haste makes waste* (haste spoils the job/work) is perfectly applicable to scientific research processes and projects.

The university scientific research is also the field of its own competition: the faculties fiercely fight for academic promotions. On top of these all, universities, under budgetary constraints, conduct their activity (scientific research included) more and more by projects—which are considered more effective and efficient while managing resources: project management must achieve best compromise between time and cost of resources, yet reaching the quality objective set. Additional time pressure and challenges are brought by current AI-based technologies in academic environment (see Additional Reading section).

The dynamic of scientific publications follows the general trend of technology development and associated R&D investment. *The Economist* (2024a, p. 62) shows that higher-education institutions across the world employ 15 million researchers that “produce five times the number of papers each year. [...] In theory, therefore, universities should be an excellent source of productivity growth. In practice, however, the great expansion of higher education has coincided with a productivity slowdown”. Arora, Belenzon, Cioaca, Sheer and Zhang (2023, p. 38) argue that “sluggish growth in productivity over the last three decades or more in the face of sustained growth in scientific output” happened because abstract ideas (i.e. generated by PhD research in universities) are difficult to use. Then the firms “appear to lack the absorptive capacity to use externally supplied ideas unless they are embodied in human capital and inventions” (*Ibidem*, p. 39).

However, amid the general trend that features booming volume of publications, (Economist, 2023a) highlights that publications related to significant scientific advances are not progressing at similar pace; moreover, their proportion is going down. Even more alarmingly, Park, Leahey, and Funk (2023, p. 138) show that “slowing rates of disruption may reflect a fundamental shift in the nature of science and technology.”

This state of facts and affairs invites to careful examination.

Getting different results than thought and planned is an old story, in the process of scientific research either, even it is organized almost exclusively by research projects, which means managing research process in a critically time manner. Higher pace and increased pressure on researchers suggest that, regardless the reasons, time management deserves a closer look.

The literature on *time management*, in general (Claessens, Van Erde, Rutte, & Roe, 2007; Chase et al., 2013) and time management for academic performance (Nasrullah & Khan, 2015; Khan, Ashraf, & Nadeem, 2020; Ghafar, 2023)—in medical higher education in particular (Elmahdy & Answer, 2023)—does not reach the sensitive point of top academic research (PhD research projects). Putri and Mahmudah (2021) studied research projects as a requirement for graduation. Research productivity was the research focus for Chase and colleagues (2013) who developed a comprehensive list of time management strategies in this respect.

On the other hand, *project time management* is subject of concern, mostly in construction projects (Solís-Carcaño, Corona-Suaréz, & García-Ibarra, 2015) or software and knowledge-based projects (Wu & Passerini, 2013) are the topics of interest.

Despite its importance, less so the *time management in academic research projects* is a study focus. One reason may be that research accuracy prevails over time and cost, and another reason indicates that setting the right priorities is more important than time management (Covey, Merrill, & Merrill, 2015): in other words, importance dominates urgency—which seems to be perfectly true in academic research projects. Probably both are right, considering the “third generation” of time management approach: “The third generation approach is ‘planning, prioritizing, and controlling’. If you’re in this generation, you’ve probably spent some time clarifying your values and priorities.” (*Ibidem*, p. 22). Covey admits the limits of the third generation (“it gives the promise of achievement ... but it doesn’t deliver”) and concludes this: “There’s clearly a need for a fourth generation [...] which requires] a fundamental break with less effective ways of thinking and doing ... We need to move beyond time management to life leadership—to a fourth generation based on paradigms that will create quality-of-life results.” (*Ibidem*, p. 31).

On the way to the fourth generation of time management, Katz (2016) conducted a comprehensive and meaningful study (as far as our scope of work) including 1013 Israeli and 457 Western European PhD candidates.

The extended sample included both science and engineering doctoral candidates and social sciences and humanities doctoral candidates. Based on the study findings (regardless the country of origin and background, doctoral students “have no training or expertise in managing a doctoral research project”) Katz (2016, p. 105) suggested that “all doctoral candidates be taught basic research-project management”. Notably, since 2019 the university in which our study was piloted has introduced Project Management as a mandatory subject during the first semester for all doctoral students enrolled.

According to triple helix model (Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2004; Nakwa & Zawdie, 2016) modern universities have a triple mission (education, research and their “third mission” contribution to society). While the education is probably the most visible and studied (e.g., Ryttilähti & Lokkila, 2024; Kokoglu, 2024) and its contribution to the research process itself is undeniable (e.g., Economist, 2023b), the focus of this chapter is on the scientific research process within higher education institutions, relationships among researchers and their mentor-disciple relationship (PhD supervisor–doctoral student)—particularly on doctoral research projects and their interactions with other university projects (*Table 1*)—which is our scope of work (shaded box).

Table 1.
The scope of work, in the framework of scientific research typology (schematized).

Type of organization	Type of activity	
	Teaching	Research
Higher education institutions (universities)		Doctoral research projects (either theoretical or practical)
		Master-level research assignments & dissertation projects
		Other education-related research activities
		Other community-oriented research projects
Other research institutions		Various types of research institutions – which are not under scrutiny (not our scope of work)

It is beyond the scope of this study to survey other research institutions or to discuss issues related to the fraud-distorted and fake-polluted scientific production, despite these worrying phenomena (Economist, 2024b). While the conflicts between organization and projects are already a topic of studies, mainly for cultural reasons (Rosenbloom & Markus, 2010), the conflicts between organizational projects are less so.

Our specific interest is on interactions (not necessarily conflicts) between doctoral research projects and other projects initiated by the university, projects in which PhD students become eventually engaged. The direct consequence is the dual role that doctoral students must play. Besides usual management conflicts between organization and project, intercultural and inter-professional conflicts (Scarlat & Sârbu Bărar, 2023), this study is concerned by interactions (not necessarily conflicts) between projects within same organization (higher education institution), particularly by effects of interactions between doctoral research projects and other projects initiated in the same university.

These interactions were experienced by author and their effects eventually became subject of an explorative, pilot study. They are part of the larger theoretic area (role conflicts). As such, the theory of role conflict covers a larger area: from work-family conflicts (e.g., Soltani, Hajatpour, Khorram, & Nejati, 2013) to working students (Fernandha & Grasiawaty, 2021) to intraorganizational role conflicts (Asfahani, 2022).

For longtime, the role conflict and role ambiguity were studied by House and Rizzo (1972) as “critical variables in a model of organizational behavior”, while the antecedents and consequences of organizational role conflicts were under scholars’ lens as well (e.g., Miles & Perreault Jr., 1976).

Ebbers and Wijnberg (2017) studied a particular type of dual-leadership structures specific to film industry, yet an interesting situation that requires special attention: the reason behind the potential conflict is always of managerial type, and solution is almost always art of negotiated communication between strong characters and personalities, on the background of weak, too flexible or total lack of sharp job descriptions.

Tummers, Vermeeren, Steijn, and Bekkers (2012) conceptualized the role conflicts at policy level and constructed test scales to measure “three types of role conflicts: policy-client, policy-professional and organizational-professional role conflicts”. Fichter (2010) studied a variety of effects of role conflicts and ambiguity, negatively affecting job satisfaction (ending in burnout) in a sub-industry (financial services). Arun, Begeç, and Okun (2021) propose a novel perspective on role conflict, which is applicable, to a certain extent, to university environment at its top research level (PhD students are, in principle, innovative by definition), despite its non-academic surveyed area (intrapreneurial characters in organizations).

Even the role conflict and role ambiguity of academic staff in research-intensive UK universities were investigated by Schulz (2013), the doctoral students and their research projects were not under scrutiny. The literature on Romanian universities is also scarce.

Consequently, because university is the place where *haste makes* not only *waste* but also *facilis descensus Averno*, our study is concerned with interactions of organizational projects (doctoral research projects included) in the higher education environment.

The remaining of this chapter is dedicated to a pilot study conducted by the author.

3. METHODOLOGICAL APPROACH

This chapter looks at a less explored, narrow research environment, at a micro-level: PhD research projects conducted in a doctoral school from a relatively large science and technology university. More specifically, this paper opens a window for discussions on the influence that other university projects (all aligned to the university R&D strategy, theoretically) may have on the doctoral research projects.

The idea of this explorative pilot study has sparked after several observations (accumulated in time) related to not-as-expected results of three doctoral students (call them A, B, C) under own supervision—specifically one-year-delay in doctoral thesis defence and several delays or even failures in the dissemination of their scientific production (*Table 2*).

Table 2.
Unexpected negative results reported in case of three PhD students (early 2024).

Doctoral students	Enrolment [from–to/extended]	Observed by PhD supervisor
A	01.10.18–30.09.21/extended ‘23	1 year overdue in PhD thesis defence & publication of 2 papers delayed
B	01.10.20–30.09.23	Publication of 2 papers failed
C	01.10.22–30.09.25	Publication of 2 papers delayed

As the single common element in all these cases was the students' engagement in two national projects initiated by the university (called them N1 and N2) it was quite normal to pay closer attention to all cases in which doctoral students were engaged in other projects initiated by the university (other than their own doctoral research program).

An empirical but systematic mixed approach was considered, including both secondary (literature survey) and primary research. Following to short survey of literature on time management (specifically time management) and role conflict and ambiguity focused on higher education universe it has become clear that:

- Project management skills are important for all PhD students, regardless their background and careers.
- Setting right priorities is even more important than rigid time-planning.
- Neat project role definition is key to avoid role ambiguity.

Considering the literature gap at the intersection of project management, doctoral research projects, and *two-project roles conflict* (all in higher education environment), as well as the initial data collected in this respect (that indicate towards deeper investigation on possible role or management conflicts between two projects in same organization), a grounded theory type of research (Glaser & Strauss, 1967; Strauss & Corbin, 1994; 1998) is probably suitable.

Despite its critics (e.g., Allan, 2003), the grounded theory was revived as Mills, Bonner, and Francis (2006) have developed the constructivist grounded theory, based on pragmatism and assuming that neither data nor theories are discovered, but are developed by researchers because of their interactions with on field research subjects (participants).

The relatively small size of available doctoral students (a target group of 7) made an experiment impossible (no control group in place).

Considering the research circumstances, the time was probably right opportunity for the study, and the place was a premiere (as no such study was conducted before in Romania), being a good start for comparative studies.

Next to the literature survey this study has had three main stages: (i) Defining the core concept (project interaction) in practical terms; (ii) Formulating the research questions; and (iii) Choosing the methods and instruments for collecting data related to the target group.

3.1. Defining the PhD project interaction

For this study, the PhD project interaction is defined as active engagement of a PhD student in another project of the university, for a limited period during their doctoral studies (in this study, interactions were from 1 to 15 months).

The effects of interactions are scrutinized from the doctoral projects' standpoint; yet from both doctoral supervisors' and researchers' perspectives (Lee & Bongaardt, 2021).

The effects can be positive if they facilitate the doctoral project progress; negative in the opposite case; or neutral if no significant effect is reported.

3.2. The research questions

If objectives of all university projects (and, implicitly, objectives of doctoral research projects) are aligned to the university strategy (and its strategic objectives), the specific research questions in this pilot explorative study are mainly qualitative:

- (i) How could the effects of interactions be measured?
- (ii) Are the effects of interactions always positive?
- (iii) If there are negative effects of interactions, then which are the reasons behind them?
- (iv) Are there any solutions to avoid the negatives or, at least, to mitigate them?

3.3. Research Methods and Instruments

The study included both primary and secondary research (literature survey), which is rather scarce (Ling & Livingston, 2024). This study relies on primary research methods mainly: directly observed and personally experienced doctoral projects in a Romanian university environment, completed with semi-structured interviews with doctoral students.

An interview map (guide) was developed for this purpose (*Table 3*).

Table 3.
Interview guide for PhD project interactions.

Section	Research issues	Details
0	Demographics	Age, gender, PhD student status
I	Work experience (other than current PhD research project)	Focus on work experience as: - research-related work as compared to the total work experience - project work experience as compared to the total work experience - work as decision maker (manager) - work as researcher in organizations, type and size - work in research projects – position and duration
II	Specific interactions with university projects (more than one interaction is possible for one PhD research project)	Active in other project/s of the university (duration, period) for a limited period, during doctoral studies as: - expert or specialist (specific terms) - researcher (specific terms) - trainer - trainee - resource person - other type of participation ...
III	Notable experiences	Selection of top three: - positive experiences - negative experiences - other (neutral, mixed, ...)
IV	Impact on PhD students' projects	Value added to own PhD research project – concrete, in specific terms
V	Major lessons learnt	(Open)
Other comments		Other details, explanations, and arguments

4. AN EXPLORATIVE STUDY ON DOCTORAL RESEARCH PROJECTS

During the period under scrutiny (18 months: 1 October 2022–31 March 2024), 15 doctoral students (enrolled to pursue a PhD degree in engineering sciences) were engaged in different phases of their PhD projects. From this pool, 7 doctoral students were identified as subjects of interactions (as defined in this study), and their projects were anonymized: PhD1–to–PhD7.

Notably, the three doctoral students originally observed (*Table 2*) are included.

The seven doctoral students were engaged in four other projects as follows: one international-level project (marked I) engaged 3 PhD students, two national-level projects (marked N1 and N2, already mentioned in comments to *Table 2*), and a single university-level project (U) which engaged one doctoral student. In other words, the PhD students' projects interacted with four other projects initiated in their university.

By duration, there are two categories of interactions: short-term (one month) and longer-term interactions (over one year: 12 or 15 months).

Table 4 depicts these interactions, by project types, including durations of the corresponding interactions.

Table 4.

Seven cases of interactions between PhD research projects and other university projects (durations included).

PhD Projects	Planned duration of the PhD research project [from–to/extended]	Estimated durations of interaction with other university projects			
		I	N1	N2	U
PhD1/A	01.10.18–30.09.21/extended '23		12 months		
PhD2	01.10.19–30.09.22/extended '24	15 months			
PhD3	01.10.20–30.09.23/extended '24	1 month			
PhD4/B	01.10.20–30.09.23		12 months		
PhD5	01.10.21–30.09.24	1 month			
PhD6/C	01.10.22–30.09.25			15 months	
PhD7	01.10.22–30.09.25				1 month

In general, one-month interactions were international exchange visits and study tours, excepting U project, which was organization and participation at a local promotion event (research fair). Longer-term (12 months) interactions meant participation in many routine project activities as meetings and events as well as workshops and training sessions (e.g., developing entrepreneurship and pedagogical skills). N2 interaction involved secondary research (literature survey) and production of research reports, which are related and may be useful to the doctoral project.

Qualitative by nature, this study is balanced in that respect of measuring the effect of each interaction: from both perspectives: PhD student and PhD supervisor.

From PhD student's standpoint, the assessment is descriptive and qualitative (answers to open questions during interviews), and expectedly favourable – viewed through the lens of personal career development (for most of them it is a novel experience).

However, to have an overall quantitative measure of satisfaction because of interaction, the doctoral students also provided an overall score, subjectively, as a quantitative measure of their level of satisfaction on a scale going from positive to negative feelings (3=highly positive, 2, 1; 0=neutral; -1, -2, -3=highly negative).

From PhD supervisor' perspective, the effects are primary quantitative (therefore more objective), in terms of the doctoral project deliverables: deadlines research progress reports and scientific production (i.e. conference proceedings, journal articles, etc.) against the research plan of each PhD student.

The results displayed in *Table 5* answer to the **first research question (i)**, highlighting the main quantitative parameters that can directly and objectively be measured.

Table 5.
Effects of interactions between PhD projects and other university projects.

PhD Project	University project	PhD student perspective [1-to-3 score]	PhD supervisor perspective	
			PhD thesis defence	Scientific production & dissemination
PhD1	N1	fairly positive [1]	1 year overdue	Publication of 2 papers delayed (3, 6 months)
PhD2	I	highly positive [3]	1 year & 6 months overdue	-
PhD3	I	highly positive [3]	6 months overdue	Publication of 1 paper failed
PhD4	N1	fairly positive [1]	-	Publication of 2 papers failed
PhD5	I	positive [2]	-	-
PhD6	N2	positive [2]	-	Publication of 2 papers delayed (9, 12 months)
PhD7	U	fairly positive [1]	-	Publication of 1 paper delayed (6 months)

The examination of *Table 5* also provides a short answer to the second **research question (ii)**: no, the effects of the interactions are not entirely positive. A more detailed answer is even divisive.

PhD students' assessment on their engagement in other projects is positive (despite having a negative scale available) although gradual (1-to-3). Oppositely, the PhD supervisor assessed the interactions' negative effects: hard delays (overdue deadline for thesis defence), which required extension procedures (in three cases), as well as failures in scientific production and dissemination of the research results (five cases, with different intensities, measured in number of papers that missed the submission deadlines, or failed completely).

Notably, any delay in the research dissemination means delays in the research process itself.

As opposed to PhD5 project (student actually) who assessed the interaction positively with no negative effects (*Table 5*), the results of PhD2 and PhD3 (shaded)—yet all doctoral students referring to interactions with 'project I'—deserve special attention because they display extreme split between PhD students' highest score for assessing the project experience (+3) and devastating effect on their PhD work (in terms of both research dissemination and overdue PhD thesis public defence).

Could it be the effect of scholarship effect awarded through project I? Probably.

Hence the inference that *negatives in the doctoral process have not much to do with the quality of university projects* (evidenced by the positive scores) but the *resources (mostly time) dedicated to university projects were "stolen" from the already planned resources allocated to PhD projects*.

The interviewees' comments converged to same conclusion (*Appendix 2*):

"Inclusion of mandatory courses that do not align with the specific objectives of the doctoral project introduces a challenge that extends beyond academic requirements. Such compulsory courses may result in a misallocation of time and resources." (PhD4)

“Being required to participate in Z events that do not align with the objectives of doctoral projects can introduce complexities and challenges for individuals involved. This obligatory involvement in unrelated events may divert time and resources away from the doctoral project's core focus, potentially impacting its overall efficiency and success. Such a situation can lead to a sense of frustration and inefficiency, as participants may find themselves navigating through activities that do not contribute directly to their doctoral project's advancement.” (PhD4).

“Since I am not a very flexible person; I like to be punctual and do not appreciate changes in plans. Within the Z project, there have been situations where the plan underwent changes that, for me, resulted in time and energy losses. Once it happened that material which I had already written became obsolete.” (PhD6).

5. RESULTS DISCUSSION AND RECOMMENDATIONS

To answer to the third **research question (iii)** and to identify the reasons behind the negative effects of the interactions that were reported, a case-by-case discussion on the matter is needed.

Overall, the results of shared opinions are not surprising, as standpoints of PhD students and their supervisors are different or even divergent (individual versus PhD project), and so the assessment criteria, objectives, and metrics are.

While PhD students assess the effect of other projects of the university on them (as individuals), the PhD supervisors (under the pressure of observing the administrative milestones) perceives negative effects on the PhD project, which is their core responsibility (in quantitative terms of project management: missed and overdue deadlines and objectives). Nevertheless, it is meaningless to assess which of them is dominant.

Among other reasons mentioned during interviews:

- Beside durations, interaction circumstances are different in each PhD project.
- Besides influence of ‘other projects’ there are other influencing factors (causes of negative effects), which might become significant (PhD topic, PhD student’s interest, experience, family and work environment, etc.)
- Interactions themselves have different natures and peculiarities.

As far as doctoral students’ feedback on the effects of interactions, the positive opinions (*Appendix 1*) versus negative opinions (*Appendix 2*) look rather balanced (yet the positives outnumber the negatives). However, deeper qualitative analysis indicates that negatives are more elaborated formulations focused on essential elements of the PhD projects, while negatives are more formal and oriented on self-satisfaction generated by engagement in Z projects (generic name for other university projects, other than own PhD research project). One pair of examples is relevant:

“Participation in an international program not only has broaden academic and professional horizons but also offered rich cultural exchanges.” (PhD5, *Appendix 1*).

“Frequent encounters with a multitude of presentations and side discussions that deviate towards content that is unrelated to doctoral research can be a significant challenge. This scenario not only dilutes the overall focus of the discussions but also poses a potential hindrance to the efficiency and productivity of the interactions. When faced with a barrage of presentations and discussions containing irrelevant material, the essential objectives of the gatherings may become obscured. The sheer volume of information, coupled with divergent tangents, can lead to a diffusion of attention and effort, detracting from the core goals and themes intended for exploration.” (PhD4, *Appendix 2*).

Both types of opinions are honest. Nevertheless, they explain not only the satisfaction and positive opinions about being involved in other projects (well-designed although), but also a key-conclusion of the findings of our study: *the unexpected negative outcomes in PhD research programs* (delays in observing the deadlines of scientific production and scientific reports, culminating with delays in finishing and defending their doctoral theses) *have their roots in wrong setting of priorities* (and not necessarily in bad time management).

Another important point to make is related to who is really the decision maker in PhD projects: PhD student or PhD supervisor? This is an issue symmetrical to the role conflict, which is also related to right and sharp design of job descriptions and project roles. In any case, the pivotal role of the PhD supervisor must be emphasized. He is the one that should support PhD student to prioritize and balance his responsibilities (even when the roles are neither right nor sharp designed (or, even worse, the roles are not there at all).

Regardless PhD supervisor's subjectivity, it is not clear—it is quite strange—why doctoral students do not seem to care much about their failures working on their doctoral research projects, while enjoy the positives of other projects.

Could these be the “good intentions” that “pave the road to hell”?

5.1. Recommendations

The results are not definitive, but they allow the formulation of several concrete, core-recommendations centred on better coordination between PhD research projects and university projects, mainly at the management level, to avoid or mitigate the negative effects (**research question iv**):

- Themes of PhD research projects were already set when doctoral students are invited to join [other] University projects, in many cases just to complete the number of participants (target group). Then: invitation should be selective (restricted to projects with aligned objectives, only).
- This invitation should be made *via* Doctoral School/s; and participation of the PhD student/s in [other] University project/s should have the formal agreement of their PhD supervisor/s.
- Before agreeing, PhD supervisor/s should be informed in advance about the activities their PhD student/s have to complete during respective interaction period.
- A formal communication channel and clear communication protocols between the University's project manager and PhD supervisor should exist for the duration of interactions, at least.
- PhD supervisor should be informed in a timely manner about activities completed by the PhD student (while the University project advances). None of these happened in the cases discussed.

It is well understood that a series of basic principles of management in higher education (research included) are respected:

- Objectives of research projects are aligned with University's strategic objectives.
- Research objectives of the University are in line with the needs of industry.
- A proper constitution of the University is in place, to regulate the relationships organization-projects and detect possible conflicts in their early stages.

6. RESEARCH LIMITATIONS AND FUTURE RESEARCH

Expected correlations between durations of interactions and delays in doctoral research projects were not identified, given the small size of the group investigated. Larger groups or samples will probably reveal such correlations.

The number of cases analysed is a limitation; yet the findings open further research paths for longitudinal and mainly transversal studies—extending the investigation to other domains of doctoral research—other than engineering sciences (management and industrial engineering, in particular) as well as to other universities. In-depth studies, by types of interactions, are also possible.

It is important to mention that data collected from a limited number of cases do not allow identifying correlations between interaction durations and interaction effects (neither positive nor negative ones). However, possible correlations between interaction durations and their negative effects (as overdue deadlines for doctoral thesis defence and/or dissemination papers) might be topics for further studies.

Nonetheless, it should be said that negatives reported are just instances, among many successful stories (in which interactions with other University projects stimulated the progress of doctoral research projects).

The current study was a premiere (as no such study was conducted before in Romania). Its approach can be a good start not only for deeper, longitudinal, and extended research, but for future comparative studies as well.

7. CONCLUSION

Besides the approach of this narrow research area and associated methodology, this piece of work reveals novel types of inter-project tensions and conflicts within higher education institutions. The research questions were addressed, and all answers provided, thus research objectives were matched. However, new questions arise, and paper limitations point to further research directions.

The findings (typology and measurement of PhD project interactions; reasons behind the negative effects of interactions—among them) are critically useful to doctoral schools and PhD supervisors as well as to major stakeholders: higher education strategists, policy and decision makers, administrators and research managers. The set of recommendations goes to them.

The conclusion looks like a snowball effect: a small piece of snow which can cause a catastrophic avalanche. The serious failures of doctoral research projects have causes in careless design of project management structures (i.e. hierarchies, communication protocols, and alike), poor priorities setting, and lack of attention paid to alignment of project objectives with strategic objectives of the university—all appearing to be easy-to-do things in novel and attractive projects. Don't they look like *good intentions*?

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APPENDIX 1

Examples of PhD students' positive feedback on their engagement in projects [called Z generically], different than their own doctoral research project

- | |
|---|
| <ul style="list-style-type: none">▪ “Interaction with Z projects might grant access to specialized facilities, equipment, or datasets that significantly enhance the quality of research.” (PhD1)▪ “Networking opportunities: collaborating with other projects can create opportunities to network with established researchers, potentially leading to future collaborations or job opportunities.” (PhD1)▪ “Interdisciplinary collaboration: engaging with projects from different academic disciplines allows for a broadening of perspectives and approaches.” (PhD1)▪ “Interdisciplinary collaboration on sustainable energy solutions was an opportunity to collaborate with researchers from the sustainable energy initiative. This collaboration not only enriched my research but also broadened my perspective on addressing real-world challenges.” (PhD2)▪ “Collaboration with engineering department resulted in a joint publication in a reputable journal and presentations at an international conference. The exposure and feedback received not only enhanced the quality of my work but also allowed me to establish valuable connections with researchers from different corners of the globe.” (PhD2)▪ “I had the opportunity to interact with people from other countries and observe their educational system as well as their perception on topics related to green energy and environment protection.” (PhD3)▪ “The recreational activities represented a good chance to get familiar with other cultures. The total project time was well balanced between these activities and the actual presentations, meetings, and visits.” (PhD3) |
|---|

- “Networking with PhD peers from diverse international universities offer a wealth of benefits that extend beyond the immediate academic context. This chance to connect with individuals in the global academic community is a gateway to a myriad of opportunities, fostering both personal and professional growth.” (PhD4)
- “Networking with professors from different countries adds a layer of richness to this experience. Connections with academics open avenues for mentorship, guidance and exposure to diverse academic traditions and approaches. This global engagement allows assimilation of varied viewpoints, contributing to a more comprehensive understanding of one's field of study.” (PhD4)
- “Participation in an international program not only has broaden academic and professional horizons but also offered rich cultural exchanges.” (PhD5)
- “Networking with fellow researchers and students from various countries provided me with valuable insights into different approaches to sustainability and renewable energy.” (PhD5)
- “Conducted online or in person, work meetings were mutually agreed upon with each member, based on their schedule and needs.” (PhD6)
- “Knowledge transfer and networking are the most positive results of interaction. Participation at Z common events, conferences and workshops generated opportunities to share ideas, get feedback, and make connections.” (PhD7)

APPENDIX 2

Examples of PhD students’ **negative** feedback on their engagement in projects [called Z generically], different than their own doctoral research project

- “At times, the meetings in Z project felt slightly political with local public figures attending events.” (PhD3)
- “Although this is a personal negative experience, traveling to the location of the Z project was difficult.” (PhD3)
- “Being required to participate in Z events that do not align with the objectives of doctoral projects can introduce complexities and challenges for individuals involved. This obligatory involvement in unrelated events may divert time and resources away from the doctoral project's core focus, potentially impacting its overall efficiency and success. Such a situation can lead to a sense of frustration and inefficiency, as participants may find themselves navigating through activities that do not contribute directly to their doctoral project's advancement.” (PhD4)
- “Frequent encounters with a multitude of presentations and side discussions that deviate towards content that is unrelated to doctoral research can be a significant challenge. This scenario not only dilutes the overall focus of the discussions but also poses a potential hindrance to the efficiency and productivity of the interactions. When faced with a barrage of presentations and discussions containing irrelevant material, the essential objectives of the gatherings may become obscured. The sheer volume of information, coupled with divergent tangents, can lead to a diffusion of attention and effort, detracting from the core goals and themes intended for exploration.” (PhD4)
- “Inclusion of mandatory courses that do not align with the specific objectives of the doctoral project introduces a challenge that extends beyond academic requirements. Such compulsory courses may result in a misallocation of time and resources.” (PhD4)
- “Within the Z project, an initial activity involved identifying articles from relevant databases. I faced difficulties in this stage because I did not have free access to certain relevant databases, making the task more challenging.” (PhD6)

- “Since I am not a very flexible person, I like to be punctual and do not appreciate changes in plans. Within the Z project, there have been situations where the plan underwent changes that, for me, resulted in time and energy losses. Once it happened that material which I had already written became obsolete.” (PhD6)
- “Even though the activities included in the Z project are present in the initial plan, they have undergone slight deadline modifications. This has provided us with more flexibility to address challenging aspects, but as someone who appreciates plans, it did not help me much.” (PhD6)
- “Interaction between my doctoral project and Z project displayed significant divergences regarding objectives. In addition to diverse own interest, divergent opinions can negatively impact the results of the doctoral project.” (PhD7)
- “Interaction between the technology-based doctoral project and Z project generates communication obstacles that hinder interdisciplinary collaboration.” (PhD7)

¹ *Facilis descensus Averno* (Latin): *The path to ‘underworld’ is easy* (Virgil, Aeneis, Book VI, line 126, 29–19 BC).

² This chapter is an updated and extended version of a previous paper (Scarlat, 2024).

Chapter # 42

***INCREMENTA ATQUE DECREMENTA*¹...** **MANAGING THE UNIVERSITY RESEARCH CENTRES** **ALONG THEIR LIFECYCLE:** **Three Cases and a Common Administrative Issue**²

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ABSTRACT

This chapter raises a specific question: Is there any common reason behind cases of failure encountered in higher education research centres or laboratories? The purpose is to launch a discussion about reasons behind unexpected failures of some university research units, with the objective of *identifying possible administrative and management causes*, possibly a common reason (either internal or external). As methodology, the study is qualitative, using both secondary (literature review) and primary research (empirical investigations). The method (observation) used three case studies (i.e. university research centres that failed). They were directly observed and/or personally experienced instances in the Romanian university environment – over a relatively long period of time (1980s–2000s). The empirical data were analysed through the lens of the organizational lifecycle. Regardless of their diverse age and size, mission and profile, and phase of growth in their lifecycle, administrative decisions were found as common type of cause of ending the activity in each case explored. The concluding remarks are focused on a set of recommendations centred on the main findings – to be recommended to the stakeholders: higher education policy makers, administrators and research managers.

Keywords: university research centre, research and didactic laboratory, organizational lifecycle, growth-induced crisis, university administration and management, management principles.

1. INTRODUCTION

This chapter is not about the rise and fall of empires or the decline of great powers (Rapley & Heather, 2023) as the metaphorical title might suggest, but about managing contemporary, less prominent organizations—like university research centres—along their lifecycles. Yet there is one similarity: organizations, like more complex systems such as empires and great powers, have their own lifecycle (Greiner, 1989; Lester, Parnell, & Carraher, 2003; Phelps, Adams, & Bessant, 2007; Bento & Alves, 2014): growth and glorious periods end up less gloriously, if not in ashes. There also are lessons to be learnt in both cases, and—as The Economist's (2023) book review shows—organizations don't always collapse but reinvent themselves, survive and thrive, despite many "Thucydides traps" (McCormack, 2023) embodied by competing organizations. Analysing growth-type crises (Witt & Worch, 2023), Slywotzky and Wise (2002) have proposed financial solutions.

The chapter opens a discussion on the causes that may cause the collapse of the university research centres—despite their promising start-up—notably, from causes other than competition (“Thucydides traps”). In other words, the scope of work (i.e. failures of university research centres) is less investigated (it is rather scarce from that standpoint of literature) for at least three reasons: (i) small organizations are less studied than larger companies; (ii) the reason of failing is other than competition; (iii) the scope of work is even narrower (the higher education environment).

In addition, the smaller organizational units—research centres or research laboratories—as advanced scientific research units (limited to prominent Romanian higher education institutions) are less investigated as distinct organization structures (Scarlat, 2003a), rather than university entirely.

2. BACKGROUND

In the framework of higher education environment, the standpoint of our discourse is managerial. This is simply because the decisions (made by the research centre’s manager, within authority limits awarded by the University’s leadership) are at managers’ own hands and have immediate and visible effects.

Therefore, the main research question is this: Is there any common reason (other than fierce external competition) behind the failures (truly, seldom) encountered in higher education research centres or laboratories? If so, is it a matter of lacking professionalism or management skills; human nature or local culture; or other pressure? This seems to be a rhetorical question – as the cause could be any or a mix of them, in addition to scores of others, depending on case-by-case circumstances.

In other words, the goal of this investigation is to identify the root-cause around administration and management, and management conflicts eventually – both inside and outside university research units – yet related to the university management and administration. In addition, according to the findings, a set of recommendations for the main stakeholders (from research founders and funders to research managers) are ultimate objectives.

Considering the time dimension, from the establishment of the scientific research units to their collapse, it is essential to use the lens of Ford’s organizational life cycle concept (Ford, 2022, p. 1): “organizational life cycles [synonym: organizational life span] refers to the sequence of events from organization initiation/birth to [its] death”. This should not be confused with the better-known term “product lifecycle” (common to marketing), neither with the economic concept of “life cycle as the lifetime pattern of income and consumption” (Black, 1997, p. 270) nor with other the macro-economic concepts as “business cycle” (Pallister & Isaacs, 1996, p. 75; Black, 1997, p. 44) or “trade cycle” (Pallister & Isaacs, 1996, p. 504; Black, 1997, p. 471) – although the last two are equivalent. In micro-economic terms, the organizational lifecycle definition is equally applicable to all types of organizations, regardless the size, age and activity sector (higher education sector included). Nevertheless, even if the business life cycle is more specific (applicable to profit-oriented organizations) than organization life cycle (applicable to all not-for-profit organizations), the scientific research units from higher education institutions are somewhere in-between – for several reasons (related to their mission, funding, destination of the research outcomes, sustainability, etc.)

Churchill and Lewis (1983) synthesized contributions by Rostow (1960), McGuire (1963), Christensen and Scott (1964), Steinmetz (1969) and Greiner (1972) to their model of five stages of small business growth. Then a revised version of their model was produced (Lewis & Churchill, 1987).

Despite large acceptance, the Greiner model was criticized for being too theoretical; thus, Flamholtz and Randle (2007) arguably proposed an easy-to-apply model of growth with seven stages, based on the company revenue. Other critics (Kaufman, 1991) simply deny the active role of management and consider the longer-term success as a matter of randomness. Therefore, the theories and models of organization life cycle should be well understood and carefully applied.

Using the Greiner (1997) model, Scarlat and Şişu (2021) studied the growth phases of the companies belonging to an international group as well as the group's entrepreneurial behaviour along its lifecycle (Şişu & Scarlat, 2020). Then, in this study, for the management reasons presented, the Greiner's (1989) model is used as analysis framework as depicted in Table 1.

Table 1.
The management-oriented framework for growth study, adapted after Greiner (1997).

Management practices	The five phases of growth				
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
	Growth by creativity	Growth by direction	Growth by delegating	Growth by coordination	Expansion & collaboration
Management focus	'Make & sell'	Operations efficiency	Market expansion	Organization consolidation	Problem solving & innovation
Organizational structure	Informal	Centralized & functional	Decentralized & functional	Line staff & product groups	Matrix of teams
Style of top management	Individualistic & entrepreneurial	Directive	Delegation	'Watchdog'	Participative
Control system	Market results	Standards & cost centres	Reports & profit centres	Investment centres & plans	Mutual goal setting
Management reward system	Ownership	Salary & merit increases	Individual bonus	Profit sharing & stock options	Team bonus

Table 1 depicts the management practices associated to the five phases of growth, according to Greiner (1997). Considering that management practices define the phases of growth, the correspondence shown in the table can be used as a tool for identifying the phases of growth when the management practices are known. In specific terms, this correspondence can also be used as an analysis framework to characterize the phase of growth of a company when its set of management practices can be assessed.

The remaining of this chapter is structured as follows: methodological approach; the core primary research based on cases of failing university research centres; discussion of findings and recommendations; research limitations and further research avenues; and conclusion.

3. METHODOLOGICAL APPROACH

The investigation approach is by domain of research, from macro- to micro-level (organizational). The work is not continuous in time, yet cases happened during a relatively long period of time (1980s–2000s), before and after communism collapse in Eastern Europe.

This study relies on secondary and primary research mainly (direct observation and/or personal experience related to insulated cases) – i.e. particular situations that happened in the Romanian university environment (namely medical, engineering and entrepreneurship studies).

Secondary literature survey complements this primary research (observation), illustrating the matter under investigation.

Since the focus is on management issues, the theoretical framework used was the organization life cycle model (Greiner, 1997).

The case method serves to address the research objectives. There are three cases of university research centres with different profiles and importance (from local to national), funded from different sources, all sharing a common feature: failures after successful start (failure in terms of missing the strategic objectives, set according to their initial missions).

The failure cases were selected subjectively (by author) based on his experience and own research. The three university research centres were active in different research areas, in different circumstances at different times, and just happened to be at different levels of interest (macro- to micro- organizational level). Their presentation follows the natural order in which this chapter was developed (which just happened to be the reverse chronological order).

The subsequent section describes these cases in concrete facts, then the phases of growth are assessed by Greiner scheme (Table 1). Conclusions from each case are assessed and compared, converging to a particular root-cause that finally emerged. Depending on these findings, a set of recommendations is developed, which was the ultimate objective of this endeavour.

4. THREE CASES OF FAILING UNIVERSITY RESEARCH CENTRES

A recent piece of news with some media echo (Case 1) was the spark for this study. Two other summarized cases are symmetrically presented, on both sides of the historical cornerstone, which was the Romanian “1989 Revolution” (Case 2 right after it, and Case 3 right before). There were very different circumstances, yet similar promising starts, followed by unexpected collapse. This is an attempt to explain the collapse.

The selection of cases was based on a single criterion: the unexpected failure (i.e. the research centres unexpectedly failed, apparently with no explanation). Each of these cases deserves an extended, in-depth study. Ciurea (2022) depicts the Case 1 in more details, colours and feelings.

4.1. Case 1: A Centre for Excellence in Neurology and Neurosurgery

Established in 1975 as a national neurosurgery hospital, and extended in 1993 as an emergency hospital, this hub of medical services currently hosts the largest neurosurgery clinic in Romania. It also functions as an important advanced research, education and training centre in medicine.

In 1999–2000 the Romanian government launched a project to fund a Centre for Excellence in Neurology and Neurosurgery (CENN) in this hospital. Its aim was to provide world class medical services and conduct advanced scientific research in neurology and neurosurgery (Valcea, 2003). According to Ciurea (2022, pp. 245–248), world class medical equipment was acquired, including a Gamma Knife Surgery (GFS) system.

The CENN project was successfully completed in 2004, and officially opened by the Minister of Health in March 2005. The cost of this green field investment was €31 million for a 5,000 sqm building that included world-class medical utility infrastructure and equipment. The first patients visited the CENN, and it seemed to have a promising take off and glorious future. Unfortunately, in 2006, a government reshuffle (Minister of Health included) and an inspection by the new Health minister resulted in the hospital's downgrading. The hospital was thus turned into a regular neurosurgery hospital (emergency unit included) – as reported by Ciurea (2016; 2022). Several different opinions regarding the CENN failure were collected–seen from different angles (media, ministry of health, CENN director).

- Failure as a sustainability issue: “[CENN’s] disappearance is the result of lack of government funding” and its complex mechanism of financing via Ministry of Health and National Agency for Health Insurances (9AM News, 2006).
- An administrative decision made by a new Minister of Health (not a physician / medical doctor accidentally), who was not involved in the decision to establish and build CENN (made by the preceding cabinets), destroyed CENN (and emerging advanced neurology and neurosurgery research as non-necessary) by turning it into a regular neurosurgery hospital (Ciurea, 2022).
- Former CENN director: By introducing an emergency unit (ER), the initial function of CENN facility gradually decayed. It was “a total disappointment” because “an exceptional education and research hub in neurosurgery simply vanished. It is such a pity that initial enthusiasm at CENN inauguration [attended by former Minister of Health] has diluted in time like many other things in Romania, which had a promising start, just to disappear later. Why?” (italicized by author). (Ciurea, 2022, p. 248).

Fact is that CENN failed so quickly that it not only struggled for existence in the stage one of their lifecycle (Lester et al., 2003) but it also barely reached the early phases of small business growth (Churchill & Lewis, 1983). This rapid and unexpected extinction of CENN–recently narrated by the former CENN director–had a strong reverberation in the author’s business memory, which instantly recalled older somehow analogue cases (Case 2 and Case 3), which were the seeds of the study displayed in this very chapter.

In the CENN case it is rather difficult to discern the right and wrong between the Ministry of Health’s criteria to decide CENN founding and funding (1999–2005) and the arguments of the same Ministry of Health (nevertheless, another minister) to decide CENN downgrading (2006) and collapse eventually.

It is beyond the purpose of this study to judge that, based on limited information. However, it is surprising that such costly contradictory decisions happened. On the other hand, it was an obvious misalignment between a research project within hospital and the hospital strategy and overall strategy of the Ministry of Health. Anyway, the root-cause of the CENN collapse was external to the research centre (a strategic decision made outside CENN).

4.2. Case 2: A Center for Business Excellence

This story is older. The Romanian 1989 revolution came up with huge local enthusiasm and international waves of sympathy. The sympathy was soon followed by assistance programmes, mostly for developing the democracy, free-market economy, civil society and civic organizations. Some donors focused on reforming the education system. Co-funding business assistance centres in major universities from former communist countries in Eastern Europe (Romania included) were such projects (Scarlat, 2001, pp. 193–197).

Under these circumstances, in 1991, it was agreed (Ibidem, p. 193) that a Center for Business Excellence (CBE) to be established in a major technical University. Its aim was to stimulate and develop business education as well as support services such as consulting, training and research. Among other results, a team of local professionals and teaching staff were the beneficiaries of business management training by US university counterparts and certified as business counsellors.

A flexible organizational structure was developed by a core team of five professional and master consultants supported by an IT expert and an administrative clerk (occasionally extended to 15 people, including intern students).

In the following years, CBE has developed organically, provided business services to over 2,000 entrepreneurs across Romania and the Republic of Moldova (1998), and eventually became the hub of a national CBE network (Big, 2004).

The results of the CBE activities influenced the entrepreneurship education in Romania. The first Entrepreneurship subjects were included in the University curricula (since 2000), followed by the first Romanian books on entrepreneurship and business management (Scarlat, 2001; 2003b).

The CBE enjoyed both national and international recognition. To mention a few, member of the US Association of Small Business Development Centers, 1993; Project of the Year Award, 1997 by National Association of Management and Technical Assistance Centers from USA (Figure 1).

A decade later, the Romanian Ministry for SMEs awarded the Project of the Year to CBE for organizing Business Plan Contest for students (2008) and CBE was nominated for the European Enterprise Award, Prague, 2009 (Figure 1).

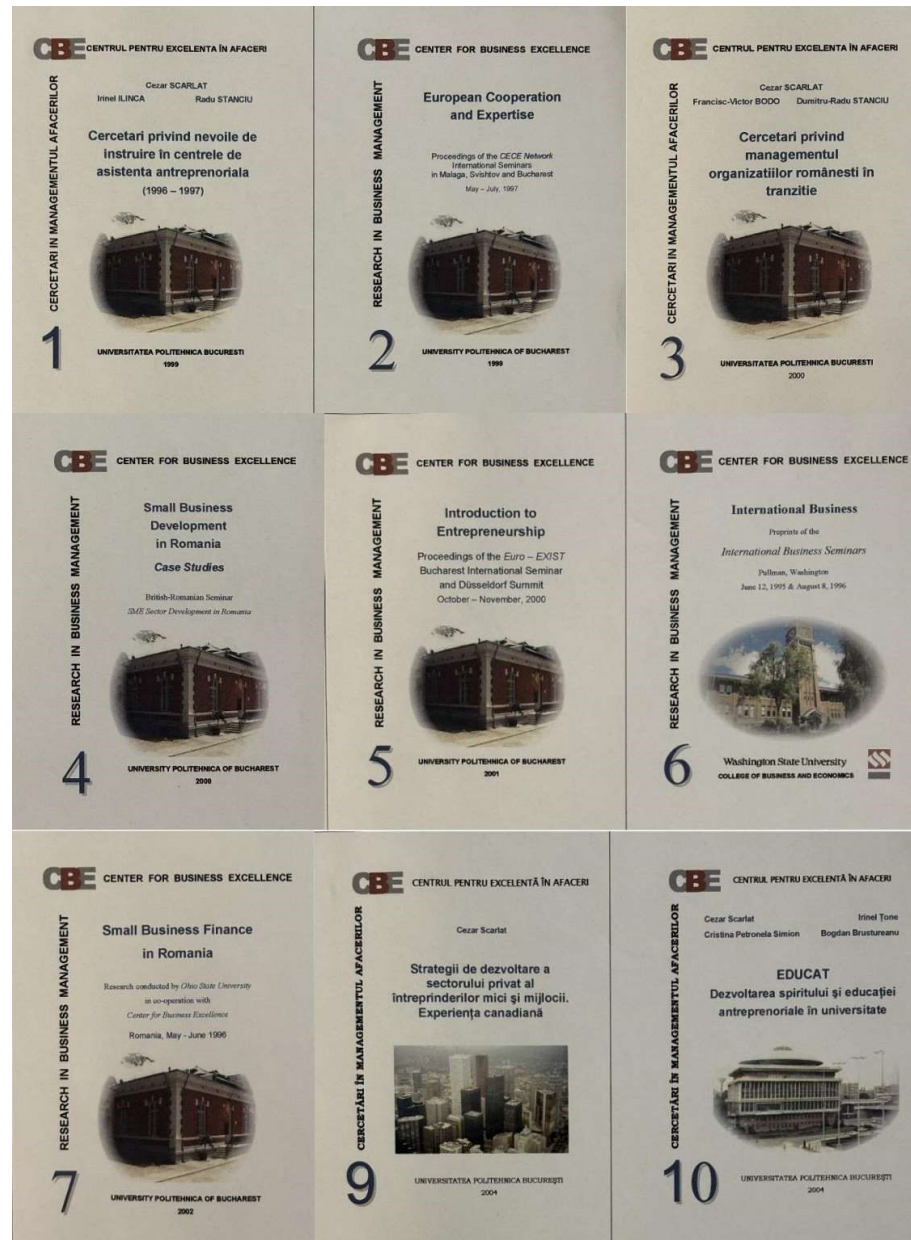
CBE staff have produced and edited ten issues of a book series: Research in Business Management, referring to research activities and projects conducted in CBE in about a decade (1996–2005) – as it is displayed in Figure 2. Two of the booklets are enlisted as Additional Readings (Scarlat, Bodo, & Stanciu, 2001; Scarlat, Țone, Simion, & Brustureanu, 2005).

Figure 1.
International recognition for CBE, a decade apart: US Project of the Year Award (1997)
and nomination for European Enterprise Awards (2008–2009).



Incrementa Atque Decrementa... Managing the University Research Centres Along their Lifecycle: Three Cases and a Common Administrative Issue

Figure 2.
Research dissemination and international visibility: CBE research book series.



By the time the Romanian Ministry for SMEs awarded the Project of the Year to CBE for organizing Business Plan Contest for students (2008) and CBE was nominated for the European Enterprise Award (Prague, 2009), the University leadership decided to dramatically (literally) change the CBE course. Without notice during the winter holidays they re-assigned

the CBE facility to a different purpose and disposed the existing materials for recycling (Scarlat, 2024).

Obviously, the CBE dissolution happened during its way towards maturity stage of the organization lifecycle (Lester et al., 2003). Hypothetically, in case of reasonable communication between CBE and University leadership, a possible transition to the fourth stage (renewal) would have been possible. At that moment, the facts demonstrate a neat misalignment of the CBE objectives with university strategy.

Further developments (the current interest of university demonstrates a clear orientation towards projects for developing entrepreneurship skills) depicts a different diagnosis: the CBE was probably born too early. In other words, the “strategy gap” is about a decade.

Despite the CBE dissolution, the CBE-trained and experienced professionals valued their experiences, continued their research projects, and extended their international cooperation – as seen in Additional Reading (Antončič, Prodan, Hisrich, & Scarlat, 2007; Scroggins et al., 2016).

Notably, on top of these, three doctoral research projects were conducted by CBE professionals, and associated PhD theses were successfully completed and defended (Scarlat, Bodo, & Stanciu, 2001).

4.3. Case 3: A Laboratory for Ergonomics

This story is even older: it started during the last decade of the communist regime and centrally planned economy in Romania—as in other east-European countries (1980s)—and ended by the end of decade, by the time of turbulent years of communism collapse (Sebestyen, 2010).

The Laboratory for Ergonomic Studies (LES) started its activity as a research centre and education laboratory associated to the Management Department within a large Romanian technical university (Scarlat, 1983a). A proper location was assigned, and the necessary support materials were prepared (Scarlat, 1983a; 1983b). LES was properly equipped (from equipment to test work micro-climate to equipment to test working skills) and staffed (laboratory coordinator, technical and secretarial support).

The number of students and faculties served by LES Increased for a few years in a row, resulting in inclusion of ergonomics in the engineering syllabi and curricula.

Then relatively quiet University elections were followed by radical changes because of the “revolution” (December 1989) that has affected the university life for years. Before disappearing completely, the LES equipment was removed and placed in a storage room (with the blessing of the new leadership of university, faculty and chair). End of the story.

By the time of its brusque collapse, LES was reporting some success, reaching about phase 2 of growth (Greiner, 1989), and organically progressing towards reaching its maturity stage according to Lester et al. (2003, p.343).

It is risky to discuss hypothetical “future LES” in the “what if” scenario. The political regime change was a historical fact, aligned with the political movements in the Eastern Europe by the end of last century. However, was the ergonomics removal an essential part of the regime change? Surely, not; it only was one of the numerous collateral and unnecessary victims. Worldwide, Ergonomics did not disappear; it only continuously adapts to the newer jobs (which is a strong reason to study this area). Then, why all these happened?

Same rhetoric question as in Case 2 emerges: Was LES born too early, just before the post-communist transition to a free-market economy?

The root-cause seems to be not only misalignment of the LES objectives with the university strategy, but also the lack of strategic vision (if not the lack of any strategy) across management levels in the University. Apparently there also were two aggravating factors at

both sides of the hierarchy, from macro- (tempestuous revolution) to micro-level (human nature oriented towards own interest); the first as an “opportunity” for the second, unfortunately.

5. DISCUSSION: FINDINGS AND RECOMMENDATIONS

The cases investigated display a large variety of circumstances (level of importance, research area, period of activity, activity peculiarities, circumstances of founding and dissolution, people involved – to name just a few).

In addition, from management standpoint, the research units under scrutiny collapsed in different stages of their life cycles.

As the selection of cases was based on a single criterion (the centres that suddenly failed, apparently with no explanation), it was challenging to conduct the investigation (yet focused on management issues) up to the point of revealing the root-cause of that abrupt change of positive course of that research centre (which was the main research objective).

A common administrative issue was found in all cases explored: an external administrative decision rather than an internal management reason for falling. To identify the reason behind those administrative decisions is a matter of further analysis and investigation—as “external” (relative to the research unit) is different in each case.

The failures exemplified are neither results of growth crisis (Witt & Worch, 2023) nor starvation cycles – as described by Lecy and Searing (2012). Not even “Thucydides traps” (McCormack, 2023). All organizations analysed enjoyed promising take-offs, and displayed organic growth, which was abruptly curbed by administrative decisions taken by supervising authorities, external to the research units and not related to their performance. The centres faced these decisions in different growth phases (Table 2).

Table 2.
Essential features of the organization lifecycle by cases investigated.

Case	Case 1: CENN	Case 2: CBE	Case 3: LES
Year established	2005	1991	1983
Owned by	Leading neurosurgery university hospital	Leading technical university	Leading technical university
Unit integrated in the structure of	University hospital under Ministry of Health	University, associated to a department	University Department
Mission	World-class neurosurgery & neurology research	Services (research, consulting, etc.) to business community	Ergonomics studies & internal training – faculties & staff
Year of extinction	2006	2009	1989
Phase of growth*	Phase 1	Phase 4 to 5	Phase 2
Reason for activity ending	CENN facility changes its mission	Facility re-assigned to different purpose & equipment displaced	Facility re-assigned to teaching activities only & equipment decommissioned
Root-cause	Decision of the Health Ministry	Decision of the university	Decision of the Department

* According to Greiner’s model (Greiner, 1997)

The examination of the quantitative assessments in Table 2 – i.e. age of research unit at the time of collapse and the corresponding growth phase (phase 1 at 1 year; phase 2 at 6 years; phase 4-to-5 at 18 years) – suggest a positive correlation which can be considered a reasonable argument for the organic growth of the research centres up to the moment of growth cut caused by upper administrative decisions. This observation would indicate that external administrative decisions were made against organic growth of the research units, regardless the timing they were active (varied from case to case).

Since the decision in case 1 (CENN) was made on political grounds (because of government reshuffling), by a novel political person with not much medical knowledge (not a physician as shown), the mechanism of that decision (even not reasonable) might be understood. In cases 2 and 3, the decision was made within university (top university level and department level respectively), but external to the research unit. Therefore, the lack of professional knowledge is out of discussion, and deeper reasons could be speculated only.

While in case 3, the collapse of communism in Eastern Europe (Romania included) was likely the force that provoked a ‘domino-effect’ across all society (and LES was a ‘collateral victim’), in the other case CBE was ‘at stake’ in the internal fight for resources: the renovated CBE facility was likely the match for a generous EU grant.

Beyond the objective assessment of the size of the strategic gap revealed in case 2 (from the organizational management standpoint), an equally objective perspective but from the larger socio-political standpoint (education included) is possible. The poisonous seeds of communism were quite uniformly spread across Eastern Europe. But they germinated differently in people and peoples. The fall of The Wall did not instantly change the two generation-long communist education. Probably it is taking two more to clean the ‘legacy of communism’. Would it possibly be that kind of *Biblical forty years*?

These two standpoints are not exclusive but complementary.

The findings allow the formulation of a set of recommendations as follows.

- The founding of such research centres (RC) in a higher education organization (HEO) should be based on longer-term vision and not on short-term interest (apparently bringing advantages).
- The RC activity and objectives must be in line with the HEO strategy.
- Environment monitoring and timely information exchange between RC and HEO would help to keep the above alignment.
- The RC should organically be integrated in the structure of the HEO; yet the HEO constitution should provide reasonable limits for flexible RC management.
- Besides functional and hierarchical management relationships, the HEO constitution must include clear (not bureaucratic) provisions related to financial relationships between HEO and RC, mainly in the perspective of RC financial self-sustainability.
- Conflicts between RC research projects and HEO (project versus organization-type) should be detected in their early stages; they can be avoided by keeping regular meetings and clear communication protocols.
- While working in a multicultural environment, developing industry-specific vocabularies would be beneficial (Scarlat & Sârbu Bărar, 2023).

There are two more notable mentions. The failure cases explored are just insulated instances, among plenty of successful stories. They were exceptions to the rule. It also should be mentioned that failures reported in the local higher education environment are not a unique phenomenon, since failures, even in the education organizations, were reported abroad as well (Ford & Andersson, 2016).

6. LIMITATIONS AND FURTHER RESEARCH AVENUES

This chapter is like an experimental film made of three short flashes taped in three different space and time circumstances (i.e. the three cases), aiming to illustrate a certain pattern, followed by some comments from ‘off’. In this respect, the subject looks like specific and restrictive (limitative).

Nonetheless, the study lens and light were focused on the main objective: identification of the common cause (an external administrative decision) and this objective was reached.

However, all other individual issues (level of the administrative decision; relationship and communication between this managerial level and management of the research unit; lifecycle and growth phase; strategy and management issues of each research unit, etc.), which were fairly presented, can be further research paths.

Each case is a whole and different story able to document a book itself (e.g., in case 1: Ciurea, 2022). Deals of data related to case 2 (Figure 1 and Figure 2) and case 3 can go in any of the directions mentioned above. As an example, the lifecycle of the research unit can be described in more details and so the phases of growth and management practices can. However, from the standpoint of the main objective of this study (limited to this chapter) and for the sake of this piece of work, it should be only mentioned that the phase of growth did not influence much the administrative decision (upper level made, external to the centre management) that abruptly ceased the existence of the respective research unit (Table 2)."

Obviously, the number of cases surveyed is a serious limitation; yet the findings open research paths for further longitudinal and mainly transversal studies – extending the investigation on more failure cases, by activity periods and regions as well as research areas. Further studies on similar cases in other countries might lead to comparative studies as well. On the other hand, in-depth and extended studies in each case with more detailed objectives might reveal novel findings (related mostly to miscommunication, misalignment of organization objectives, conflicts of management, conflicts of strategy, and even conflicting projects).

7. CONCLUSION

This chapter presents the results of a work which has reached its objectives. External administrative decisions (and not managerial internal errors) unexpectedly caused the end of activity in all cases investigated. However, depending on circumstantial peculiarities, several lessons should be learnt.

The set of recommendations can help improve the management of research units integrated in higher education organizational structures.

Despite its novelty and contribution to filling the knowledge gap related to the failures of research centres within Romanian higher education organizations, this is just opening Pandora's Box – as further questions may emerge. As such, beyond all facts, comments and recommendations rendered in this chapter—and regardless the number of failures of research units that displayed various organizational structures in relation with respective universities—isn't organizational structure itself an issue worthy for further debate? Isn't it possible that organizational structures chosen in each case to be unsuitable? Aren't there too many hierarchical levels to decide what a research unit should do?

The problem *might not be in the administrative decision but in the management structure*; how the structure of the research unit should harmoniously integrate into university organizational chart. The research structures that successfully operate in more advanced economies like US, UK or EU might be positive examples to follow. However, a US implant in a Romanian body (as CBE started) is not enough to thrive.

Finally, three comments are noteworthy:

- Usually the success stories are reported, and investigations are looking for successful people and organisations. This study follows the opposite approach.
- The failure cases reported are just instances, among plenty of successful stories.
- Despite RC failures, the RC people (mainly young professionals) ended up stronger; they are more experienced as beneficiaries of lessons learnt, hopefully.

This piece of work did not intend to become a standard study (as some readers might expect). It just happened to develop into a book chapter. Not by chance but in a deterministic manner that had a spark as a starting point: while reading Neurosurgery chapter in professor's Ciurea book (Ciurea, 2022) about the collapse of CENN. By then there were no ideas about any study, essay or paper. Nothing about any title yet. Just the feeling of 'how can this happen?' It did not last much to realize that a similar feeling has emerged, recalling my own experience in different time, space and professional circumstances, when a promising university research centre has collapsed. It collapsed unexpectedly, despite enthusiastic start-up, positive take off, good results, and development perspectives. Hence: *Incrementa*. Then *decrementa*. Keeping thinking around same question, it did not take much to add a third case to have a triad as a construction base. This chapter is a slice of the efforts to put my thoughts together in a systematic manner.

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¹ *Incrementa atque decrementa* [Latin] means the growth and decline, and it is inspired by: *Historia Incrementorum atque Decrementorum Aulæ Othomanicæ* [*The History of the Growth and Decay of the Othman Empire*] written (1716) by Demetrius Cantemir (1673–1723), Romanian Prince; encyclopaedist, man of letters and statesman who has also served as Voivode of Moldavia Principality twice (1693; 1710–1711).

² This chapter is an updated and extended version of a previous paper (Scarlat, 2024).

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