

Education Applications & Developments XI - Part I



Editor: Mafalda Carmo

Advances in Education and Educational Trends

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Edited by: Mafalda Carmo



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FOREWORD

inScience Press is delighted to publish this book entitled *Education Applications & Developments XI* 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.

This 11th volume, presented in two parts, addresses some of the most relevant and pressing issues in contemporary educational research. Through the contributions of a dedicated group of authors, this volume explores diverse dimensions of Education, fostering the advancement of knowledge and encouraging innovation in the field. Progress in education depends on the active commitment of individuals who are willing to develop creative solutions and who believe in their capacity to bring about meaningful change. In this spirit, the present volume seeks to inspire broader public engagement and strengthen collaboration within and across communities. As part of our ongoing commitment to serving society, we underscore the importance of reinforcing research initiatives, promoting education and science, and encouraging interdisciplinary cooperation. We believe that connecting diverse perspectives and areas of expertise is essential for advancing educational practices that are both impactful and inclusive.

This 11th edition is organized around four major areas within the broad field of Education: “*Teachers and Students*”, “*Projects and Trends*”, “*Teaching and Learning*”, and “*Organizational Issues*”. Part I focuses on the areas: “*Teachers and Students*” and “*Teaching and Learning*”, while Part II addresses “*Projects and Trends*” 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 2025) 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 process resulted in the publication of 27 high-quality chapters in Part I and 30 chapters in Part II. The following sections and chapter abstracts provide further insight into the content and scope of Part I of this volume.

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

Chapter 1: *The use of Aharon Appelfeld’s Adam and Thomas in literary education*; by Milan Mašát. This paper analyses the pedagogical potential of Aharon Appelfeld’s *Adam and Thomas* (2013) for Literary Education and specifies implementation across three schooling levels: early primary, lower secondary, and upper secondary. Using qualitative literary content analysis, we evaluate the novel against explicit criteria: (1) developmental fit (linguistic demands, cognitive load, scaffolding); (2) thematic accessibility and complexity; (3) ethical and historical sensitivity when teaching traumatic literature, particularly Holocaust-related content; and (4) curricular alignment with reading comprehension, literary concepts, intercultural competence, and values education. We conceptualise the text’s “spaces of indeterminacy” as structured invitations for learner interpretation, drawing on a reader-response perspective that acknowledges diverse cultural and historical backgrounds. Although the Second World War provides the setting, the narrative foregrounds agency, care, and moral growth, offering entry points for plot oriented as well as philosophically inclined students. We model grade-banded adaptations of the same passage to show progression in task complexity and sensitivity, and we outline safeguards (pre-teaching of context and vocabulary, informed choice, and debrief routines). The study provides transparent criteria and concrete pathways for age-appropriate classroom integration.

Chapter 2: *Inclusive strategies for the teaching and learning of queer-themed curricula in the language classroom - A narrative review*; by Matthys Johannes Uys. The global discussion surrounding the social challenges faced by queer identities and the incorporation of queer-inclusive curricula in educator training is extensive. Queer individuals encounter queerphobia in their daily lives, which engenders adverse experiences for queer students within heteronormative educational settings. The investigation into the inclusion of queer-themed curricula has yielded promising and beneficial outcomes. However, there remains a gap in implementing pedagogical strategies, as there appears to be a disjunction between the experience of queer individuals and their prerogative to human rights, specifically equality, within the language classroom. Consequently, there is a pressing need for further information to equip educators with the pedagogical knowledge required to integrate queer-themed curricula effectively into the language classroom. The qualitative approach, with social constructivism (as the research paradigm) and textual analysis (as the research method), makes up the research methodology of this chapter. The results highlighted and discussed strategies educators could implement in their teaching and learning to include queer-themed curricula: addressing heteronormativity, “leaning in” to discomfort, including intersectionality, reading “straight” texts through a “queer lens”, including texts with queer characters, queering queer-inclusive texts, analysing high-caliber queer literary elements (e.g., themes and characters), and creating safe zones.

Chapter 3: *Unlocking natural ability: Expanding opportunities for emerging performing arts actors*; by Limkani Sincuba. Natural talent makes the art industry richer with actors and performances. The study investigated the significance of creating opportunities for aspiring actors in the field of dramatic arts, emphasising the role of natural talent and structured training. The study adopts Howard Gardner's Theory of Multiple Intelligences as its theoretical framework. In the qualitative case study approach, twelve participants were purposively selected for the study. Data were collected through structured interview questions, which facilitated the identification of key themes through coding and thematic analysis. The findings reveal that, despite the significant challenges associated with pursuing an acting career, including intense competition and limited resources, various initiatives have emerged to support aspiring actors. Programs emphasising local theatre participation and community-based training provide essential skills and networking opportunities. The study recommends programs that prioritise raw talent and ensure accessibility in a supportive environment, where participants hone their artistic skills and develop critical life competencies, resilience, which could be essential for artists. The findings advocate for the expansion of similar initiatives that recognise and nurture natural talent in aspiring actors. The study concludes that there is a need to integrate performing arts education into community frameworks to cultivate future generations of artists.

Chapter 4: *From simulated classrooms to real-world readiness: Rethinking micro-teaching for economics pre-service teacher preparation*; by Vangile Candice Khumalo, Abelwe Maluleka, & Rhulani Maluleka. Micro-teaching provides pre-service teachers with a valuable platform to develop and refine their pedagogical skills. This chapter examines the perceptions of third-year Economics pre-service teachers at a South African university regarding the effectiveness of micro-teaching. Using semi-structured interviews within a qualitative case study design and interpretivist paradigm, and drawing on a small purposive sample of three participants, the study offers an in-depth, exploratory account of their experiences rather than generalisable findings. Three key themes emerged: confidence building, enhanced subject knowledge, and the value of feedback. The analysis is framed by Bandura's Social Cognitive Theory, highlighting the importance of self-efficacy and observational learning. Although participants recognised the benefits of micro-teaching in bridging theoretical knowledge with classroom practice and in enhancing their perceived readiness for real classrooms, they also reported challenges such as limited resources, time constraints, and rigid lesson structures. The study relies primarily on self-reported experiences, and the absence of observational or documentary data is acknowledged as a limitation. Nevertheless, the chapter offers recommendations for enhancing micro-teaching within teacher education and outlines directions for future research, with implications for policy and practice across the sector. Given the small purposive sample (three participants) and reliance on interview data, the findings are exploratory and not statistically generalisable, but they offer context-specific insights and directions for future research.

Chapter 5: *Learning analytics to support low-achieving students in programming education*; by Takuya Hasegawa & Yosuke Ito. In recent years, providing effective programming education has become an important issue in Japan. This study aimed to support students predicted to have low proficiency by analysing their coding processes. Programming lessons were conducted at a senior high school, and learning analytics were performed using both the frequency of tokens contained in the students' programs and their proficiency levels measured through assessments. Using machine learning with token frequencies as features, a classification model was constructed to identify the lower-achieving group effectively. Furthermore, by examining tokens with low coverage rates in this group and visualising their positions in the exemplar program, patterns were identified that may help pinpoint areas of difficulty. These findings suggest that the proposed analysis method can help support students at risk of low proficiency.

Chapter 6: *Cultural ontology in mathematics education: A pedagogical framework for geometry instruction in pre-service teacher training*; by Lina Vinitsky-Pinsky & Artour Mouftakhov. This study explores integrating historical perspectives into geometry instruction for pre-service mathematics teachers. Traditional curricula portray mathematics as fixed, emphasizing Euclid, Pythagoras, and Thales, while neglecting non-Euclidean contributors like Lobachevsky, Bolyai, and Riemann. Eight third-year students at Achva Academic College engaged in a learning sequence using the Discipline-Culture structure (Tseitlin & Galili, 2005) to examine shared and discipline-specific contexts, as well as contested concepts. They analyzed historical definitions of angles and expanded the DC-Structure with Non-Euclidean axioms. Guided by Cultural Ontology, students recognized mathematics as evolving perspectives. This study employs a mixed-methods approach through triangulation analysis, integrating qualitative research, ontology construction, and historical analysis. Findings showed varied engagement, fostering reflective, informed educators.

Chapter 7: *Adult education and training in Latvia: Case study of the Zemgale planning region*; by Ginta Kronberga & Monta Mantrova. Adult education and training are vital in a postmodern society; they allow not only to improve an individual's personality but also to maintain competitiveness in the labour market. The research aim is to explore issues and solutions in adult education and training within the Zemgale planning region in Latvia. The research concludes that the most widespread problem in adult education and training is a lack of strategy at all responsible levels, with main issues including coordination deficiencies among providers, difficulties in reaching the target audience due to logistical matters, and insufficient resources allocated to adult education and training. The results indicate that municipalities display significantly different models in the planning and organization of adult education and training processes, which leads to suboptimal use of local institutions for promoting adult education and training availability and long-term unbalanced approaches to adult education and training policy and

management by sectors and regions, including the planning and implementation of European Union resource grants by state institutions not delegated to planning regions and municipal NGOs. The proposed solutions include better coordination at the regional level, strategic planning, and investment in adult education and training resources, as well as innovative approaches to engaging the community.

Chapter 8: *Entrepreneurship education by Me & MyCity project*; by Auli Ojala. This study examines the Me & MyCity learning environment as a pedagogical method for enhancing working-life competencies among Finnish sixth-grade pupils. In Me & MyCity, twelve-year-old students participate in a one-day simulation in a miniature society that includes companies and public services. During the visit, pupils work in assigned roles, earn a virtual salary, and act as active citizens and consumers. The project aims to investigate the learning outcomes and experiences of both teachers and pupils. The research sample consists of 40 teachers, 220 pupils, and an additional group of 70 pupils from Tampere and five surrounding municipalities. The theoretical framework is based on the Finnish Core Curriculum 2016, phenomenon-based learning, Kolb's experiential learning theory, and Strauss's grounded theory approach. Empirical data have been collected through multiple qualitative and quantitative methods. The findings indicate that Me & MyCity is an effective and engaging teaching method that supports pupils' understanding of economic concepts, working life, and entrepreneurship. Pupils enjoy participating in the simulation and value the opportunity to work in a chosen profession. However, teaching materials are perceived as somewhat theoretical, suggesting that more concrete preparatory activities could strengthen learning outcomes.

Chapter 9: *A framework for early detection of weak signals of STEM-related aptitudes*; by Alina Florentina Grigorescu (Pîrvu) & Cezar Scarlat. The present work aims to establish a research framework and an appropriate procedure for the assessment and identification of emerging skills related to STEM (as weak signals) from primary school so that students have the necessary training and support to adapt to universities and future workplaces. As methodology, the study is based on directly observed and/or personal experienced cases in the Romanian engineering higher education as well as pre-university education cycles, which are complemented by pilot tests designed for this purpose. Secondary research (literature survey) marks the literature gap and complement the matter under investigation. Since this is a pioneering effort, several challenges are foreseen. This project can be risky in the long term because positive/negative outcomes can occur, requiring a step-by-step approach. Nevertheless, the lessons learnt, and implications are important for the main stakeholders: education policy makers and administrators, students and professors alike (Grigorescu & Scarlat, 2025).

Chapter 10: *Science communication as a field of praxis: A theoretical model of converging domains*; by Mayara de Carvalho Santos, Wilton José Diolindo Nascimento Júnior, & Gildo Girotto Júnior. Science Communication (SC) has expanded across multiple formats and platforms, but it lacks a theoretical consensus on its nature and purposes. This chapter proposes a theoretical model that understands SC not as a process or an instrument, but as an autonomous field of praxis. The model argues that SC materialises its practice at the convergence of four fields—the scientific, the communicational, the educational, and the technological—and operates through a process of negotiated autonomy. This praxis-based approach opposes traditional paradigms of discursive reformulation and genre, which reduce it to a merely instrumental view. Instead, we consider SC as an intentional and reflective action that redefines itself, its object, and its purpose. The model suggests that SC must present science in action, aim to expand the public's conceptual profile, and foster a relationship of mutual enrichment between science and society. This approach seeks to strengthen trust in science, recognising it as a pillar of a more just and democratic society. The model also offers conceptual guidance for the design, analysis, and evaluation of communication practices across diverse institutional and social contexts.

Chapter 11: *Intermediate phase teachers' knowledge, beliefs, and challenges in promoting self-regulated learning in selected South African primary schools*; by Keneilwe Agbenyegah & Bernadette Geduld. Primary schooling is a key contributor to the ongoing underperformance and broader crisis in South African education, yet despite increasing demands associated with the twenty-first century and the Fourth Industrial Revolution, it has received limited attention in developing self-regulated learning approaches. Self-regulated learning is essential in contemporary education, equipping learners with cognitive, motivational, and behavioural skills for academic success and lifelong learning. Teachers' perceptions, knowledge, and beliefs about self-regulated learning shape classroom practices and learners' opportunities to develop these skills. However, limited familiarity with SRL concepts may constrain teachers' ability to integrate SRL effectively into their teaching. Although the value of SRL is well established in the literature, less is known about teachers' understanding of SRL and their capacity to promote it in South African primary school contexts. This qualitative study explored Intermediate Phase teachers' knowledge of, and beliefs about, the value of SRL. Situated within an interpretivist paradigm, purposive sampling selected fifteen teachers from three primary schools. Data were generated through semi-structured face-to-face interviews. Findings indicate that while teachers recognise the importance of self-regulated learning and their role in fostering it, limited knowledge and training hinder effective implementation, highlighting the need for targeted professional development.

Chapter 12: *Arithmetic repetition in the teaching and learning of algebra and functions in upper secondary school - Reality status and development directions*; by Natalia Karlsson & Wiggo Kilborn. This study examines students' learning of arithmetic–algebra content, focusing on the transition from prior arithmetic knowledge to algebra in relation to how repetition is organized in teaching. The focus was on repetition of arithmetic content, as well as arithmetic repetition–concept shifts into new learning contexts, including algebraic expressions, equations, and the concept of function. In this study, teaching and students' subject-specific learning were analyzed according to the methodological design of Freudenthal's didactical phenomenology, with a focus on the relationship between the teaching of arithmetic and algebra, and Bernstein's conceptualization of the repetition–without–repetition approach, which concerns how prior knowledge should be systematized and integrated with new knowledge. The study illustrates that students' prior knowledge is used to a very limited extent in teaching and in a one-sided manner. The teaching of algebra is seen as an isolated act and has no conceptual connection to students' arithmetic knowledge. The following chapter sets out recommendations to address this problem and outlines an alternative approach to the teaching and learning of algebra and functions that incorporates repetition. The study highlights the importance of developing an alternative approach to “get through” learning-oriented repetition and teaching, grounded in a psychological perspective.

Chapter 13: *Exploring the relationship between students' mathematics self-efficacy and mathematical literacy*; by Eleni Nolka. Mathematics self-efficacy—the belief in one's ability to successfully perform mathematics-related tasks—has been consistently linked to improved mathematical performance and literacy. This study investigates the relationship between mathematics self-efficacy and mathematical literacy among Greek students at the end of compulsory education. A sample of 650 students from schools across major urban centers, small urban centers, and rural areas in Greece participated in the study. Mathematics self-efficacy was measured both as a single composite index and through four specific subcategories: (1) self-efficacy in solving abstract mathematical exercises, (2) self-efficacy in addressing real-world problems, (3) self-efficacy in mathematical literacy skills, and (4) self-efficacy in information literacy skills. The study aims to determine whether statistically significant correlations exist between students' performance in mathematical literacy and each of these dimensions of self-efficacy. The findings reveal a statistically significant positive correlation between overall mathematics self-efficacy and mathematical literacy performance. Furthermore, each of the four subcategories also demonstrated statistically significant positive correlations with mathematical literacy outcomes. These results underscore the multifaceted nature of mathematics self-efficacy and its critical role in supporting students' success in mathematical literacy, particularly as assessed in large-scale frameworks such as PISA.

Chapter 14: *Supporting science teachers to cultivate epistemic empathy*; by Valentina Bologna & Caterina Bembich. Epistemic empathy involves understanding and appreciating others' cognitive and emotional experiences during knowledge construction, communication, and critique. Lacking empathy in science education is a major issue because it causes educators to overlook or undervalue students' unconventional ideas when they stray from established scientific beliefs. Failing to acknowledge the learner's intellectual and emotional struggles can confine student ideas within rigid frameworks, hindering inclusive and equitable learning. To address this challenge, a professional development program was implemented during the 2023/2024 school year for primary and lower secondary school teachers. The program aimed to foster new teaching habits by encouraging the adoption of the Investigative Science Learning Environment (ISLE) approach. The present study sought to connect the development of these professional habits with the growth of epistemic empathy and to assess teachers' awareness of their evolution through their own reflections. Preliminary findings demonstrate that the training framework successfully facilitated the emergence of new teaching habits and enhanced teachers' understanding of epistemic empathy, highlighting the vital role of structured professional development in fostering responsive and student-centered instruction.

Chapter 15: *Integrating advanced technology for pedagogical enhancement in grade 10 accounting instruction: A South African viewpoint*; by Olwethu Solundwana & Limkani Sincuba. The study investigated the integration of technology into Grade 10 accounting instruction, examining how teachers adapted their methodologies to incorporate various technological tools, such as online platforms and interactive software, following the COVID-19 pandemic. A qualitative research approach was employed. The study adopted a constructivist learning theory. A purposive sample of 15 accounting teachers from five schools in the OR Tambo Coastal region was utilised. Data were collected through in-depth interviews. The data was analysed using thematic analysis. The study concluded that while technology integration offered significant benefits for educational outcomes in accounting, it also revealed challenges that require comprehensive training programs and strategic investments in resources. Future research could investigate the long-term effects of technology integration on learner performance and identify effective practices for teacher professional development. The study recommended ongoing professional development programs tailored for accounting teachers, prioritising resource allocation for technology access, and establishing collaborative learning communities among teachers. Additionally, training programs were developed to enhance learners' technological skills. Updating the curriculum to emphasise digital literacy and creating robust support systems for technical issues were essential.

Section 2, entitled “Teaching and Learning”, offers research about foundations in the education process itself, in various contexts, both for tutors and students.

Chapter 16: *Self-evaluation among first-year university students: Anticipated performance in academic assessments*; by Giulia Maria Cavaletto & Federica Cornali. This study explores university students’ self-perception regarding their preparation and expectations for grades compared to the results obtained in an exam. Involving 134 freshmen from a bachelor’s degree program, the survey compared students’ predictions about their grades with those they actually achieved. The results highlighted a significant discrepancy between expectations and performance, with many students tending to overestimate their own preparation, especially those with unsatisfactory results. The analysis also revealed a relationship between the type of secondary school attended and grade expectations, with students from technical and vocational schools often having higher expectations compared to those from high schools. The study suggests that a lack of familiarity with university evaluation methods and the effects of previous school socialization could influence students’ perceptions.

Chapter 17: *Developing critical thinking skills in secondary school learners using educational philosophies: South African teachers’ perspectives*; by Bianca Williams & Celestin Mayombe. Critical thinking is one of the highly recommended skills for the 21st century that young people should cultivate from secondary education to prepare them for the future of work. This chapter examines how secondary school teachers use educational philosophies in classrooms to develop critical thinking skills in learners. The study used a qualitative research approach and a multiple case-study design to understand the participant teachers’ perspectives. The study population consisted of Grade 10-12 secondary school teachers within the Buffalo City Metro (BCM) District in the Eastern Cape, South Africa. The sample size consisted of 12 teachers. Purposive sampling was used to select the participant teachers for semi-structured and focus group interviews. The study used thematic analysis methods to analyse data. The findings reveal that teachers practised social constructivism and progressivism as educational philosophies to develop critical thinking skills in their learners. The authors conclude that developing critical thinking skills in secondary school learners by using relevant educational philosophies could result in preparing them for the future world of work or tertiary education. To develop critical thinking in secondary school learners, the study recommends that the Department of Education and policymakers should implement ongoing teachers’ continuous professional development that involves hands-on strategies for teaching each subject in classrooms.

Chapter 18: *The use of grade-level readers in the foundation phase*; by Martha Khosa. Grade-Level Readers in the form of Reading Anthologies are provided in South African Foundation Phase classrooms (Grades 1 to 3) for home language learners to promote their reading interest and make teaching reading easier. However, evidence shows that teachers lack an understanding of teaching reading in line with methodologies prescribed in the curriculum. This study examines the

effectiveness of Grade-Level Reading Anthologies in impacting reading instruction and promoting reading in the Foundation Phase. A qualitative case study underpinned by Tomlinson's theory of differentiation, Vygotsky's Zone of Proximal Development and Krashen's Input Hypothesis were used to collect and analyse data in six quintile 1 and 2 (categorised as the poorest) primary schools. Grade 3 reading lessons (with grade-level readers used as the main resource during group guided reading activities) were observed. Data from the lesson observations were analysed manually by using thematic analysis. Classroom observations revealed the teachers' lack of knowledge in teaching reading and their inability to cater for differences and diversity in the classroom. In view of these findings, it is recommended that teachers be provided support through coaching from relevant stakeholders so that they can teach reading cognisant of the differences existing in their classrooms.

Chapter 19: *Through a child's eyes - Literature as a bridge to understanding PTSD*; by Yaakova Sacerdoti. This article examines a corpus of Israeli picture books for children aged 4–7 that depict fathers coping with combat-related posttraumatic stress disorder (PTSD). Written and published in direct response to the October 7, 2023 attacks and the ensuing Iron Swords War, these six works constitute the only literary corpus to date that addresses paternal combat-related PTSD in Israeli children's literature. They mark a profound cultural shift, challenging established motifs of heroism and sacrifice alongside the broader national ethos that has long shaped Israeli narratives for the young. The analysis considers these six books: *Papa Tank* (Sosonovsky, 2023), *Posti and Me* (Leibovitz & Cohen-Leibovitz, 2025), *What Happened to Or's Dad?* (Brosh, 2024), *Where Did Dad's Laughter Go?* (Tzvi, 2024), *Daddy Postamaty* (Zerach, 2024), and *Menachem's Secret Soldier* (Ramati, 2024). Together, these books trace how trauma reshapes family life - from initial harmony through paternal withdrawal and children's emotional disorientation to tentative understanding and open-ended recognition. By translating complex psychological realities into symbolic and accessible forms, the corpus enables young readers to perceive war and recovery through a child's eyes, foregrounding young children's emotional interpretations and coping strategies. These works reconfigure the canonical figure of the stoic "Israeli fighter," redefining heroism to include vulnerability, empathy, and relational resilience. Beyond the Israeli context, the study contributes to broader academic and pedagogical discourse on trauma, illustrating how children's literature can serve as a cross-cultural and therapeutic medium that equips young readers, especially those growing up amid conflict, with tools for dialogue, emotional literacy, and resilience.

Chapter 20: *Exploring the effectiveness of integrating didactic games in arithmetic lessons: A case study at the rudimentary level in South Africa*; by Fitzgerald Abakah & Albert Antwi. Primary school learners' consistent underperformance in arithmetic, mainly attributed to ineffective instructional approaches employed in mathematics classrooms in South Africa, is the impetus for conducting this study. This quantitative case study examined the efficacy of incorporating a didactic game - Magic Square - in tandem with the Gurteen Knowledge Café approach for

arithmetic instructions. Participants ($n = 31$) were Grade 3 learners from a primary school in the Northern Cape Province. Initially, learners were taught arithmetic using the traditional approach, followed by a pre-test. The intervention involved collaborative groups of 3-4 learners engaging with the new pedagogy, followed by a post-test. Kolb's experiential learning cycle served as the theoretical framework. Data collection methods included classroom observations, a pre-test and a post-test. Learners' pre-test and post-test scores were statistically analysed using the Bayesian Random-Effect Negative Binomial Model, which revealed a significant difference between the mean marks of the pre-test and post-test. The findings suggest that Magic Square is a more effective pedagogical tool for conducting arithmetic lessons at a rudimentary level compared to the traditional approach. Consequently, the researchers recommend incorporating the Magic Square as a didactic game into arithmetic instructions in South African primary schools to improve learners' performance and engagements.

Chapter 21: *Developing transversal skills through creative team building in engineering education*; by Francesca Maria Ugliotti, Michele Zucco, & Margherita Cassis. Integrating pedagogical innovations and inclusive approaches in university education supports a shift from passive instruction to active, cooperative learning and the development of transversal skills – particularly collaboration and critical problem-solving – demanded by contemporary engineering and architectural practice. This article presents an experiential team-building intervention implemented in a first-year Building Drawing course at Politecnico di Torino, designed to enhance peer interaction and cooperative decision-making between students from heterogeneous backgrounds. The experiential activity proposes a creative challenge in the field of modular architecture by using the 3D-printed basic element proposed by the architect Walter Gropius. The intervention was evaluated through a questionnaire combined with qualitative classroom observations to capture perceived learning experience and group dynamics. This experience shows how innovative teaching methodologies can strengthen relational and collaborative behaviours and, in parallel, increase student motivation, preparing learners to manage group dynamics and suggesting that inclusive, design-based team building can effectively support the development of transversal skills in AEC education.

Chapter 22: *Teaching law in the age of artificial intelligence: time for curriculum reform?*; by Allison Geduld. A revolution has been introduced by the introduction of generative artificial intelligence (AI). Generative AI systems can now perform activities relating to problem-solving and decision-making. The introduction of AI questions traditional approaches to teaching and learning but brings with it a plethora of ethical issues such as academic integrity. Curriculum policy documents on legal education in South Africa outline essential skills for law graduates such as reading, writing and research skills. None of these documents speak to the ethical use of AI tools. The central question of this study is: what aspects of legal curricula in South Africa should be addressed to adequately prepare law graduates for the legal profession in the age of AI? The first part consists of a consideration of the relevant

skills that are needed for law graduates in the age of AI. The second part evaluates the various quality standards documents on legal education in South Africa against the findings in the first part. The final section will propose recommendations for curriculum reform. This paper concludes that legal curricula must incorporate skills training aimed at the use of AI tools.

Chapter 23: *Critical thinking dispositions in the university student population: A narrative synthesis of the concept*; by Sharmila Fathima, Ron Salden, Chia Ping Lee, Terry Lansdown, & Deborah Ann Hall. Experts in the field of critical thinking (CT) make a conceptual distinction between CT skills and dispositions. While CT skills are the cognitive abilities to think critically, CT dispositions are the ingrained habits and attitudes that motivate individuals to apply those skills in given situations. Despite the rapid growth of CT research over the past three decades, most work has concentrated on CT skills rather than dispositions. Hence, there is a lack of consensus on the dispositional dimension, specifically how it is measured and how it can be nurtured by educators. This chapter addresses how CT dispositions have been defined in the literature. A systematic review methodology was used to search Web of Science, Scopus and PsycINFO databases from 1988 to 2022. Of 1014 records screened, 63 met the inclusion criteria. Findings were synthesised to create a single conceptual framework comprising 26 distinct dispositions. While our framework shows strong alignment with previous models, it adds new knowledge by highlighting the role of affective components, such as empathy. The framework provides a unified basis for advancing research, assessment, and pedagogy for CT dispositions in education settings. Moreover, critical evaluation of current measurement instruments reveals limited coverage and highlights the need for more comprehensive tools.

Chapter 24: *Extending the 2D3S4L framework: Generative AI for pedagogy, literacy, and cross-cultural English classrooms*; by Wei Zhang & Dzintra Iliško. This chapter presents the 2D3S4L instructional model, designed to embed generative chatbots into secondary English classrooms with pedagogical coherence. The model aligns teaching and learning processes across two dimensions (teachers and students), three stages of instruction (pre-class, in-class, post-class), and four recursive loops (analyze, design, implement, evaluate). Grounded in sociocultural theory and the TPACK framework, the model was implemented in Chinese secondary schools using DeepSeek and Doubao AI to support writing, speaking, and reflective reading tasks. Findings show chatbots enhanced idea generation, linguistic accuracy, and learner autonomy, while teacher prompts and scaffolded feedback were critical for effective integration. Concrete examples illustrate how chatbots facilitate task execution and deepen reflection. The chapter provides a structured framework, as well as practical guidance, on what future AI-enhanced language instruction might look like. The chapter provides not only a structured framework but also concrete suggestions for what new AI-enhanced language instruction may be for educators in the future. These initiatives set up both theoretical foundations as well as practical approaches toward the impactful implementation of AI in language learning.

Chapter 25: *The combined use of concept maps and the Kahoot gaming tool for a structured teaching of telecommunications*; by Gerasimos Pagiatakis, Nikolaos Voudoukis, Dimitris Uzunidis, & Dimitrios Karaoulanis. The chapter presents the combined use of concept maps and the Kahoot gaming tool in the teaching of telecommunications. Concept maps were used for the presentation of the overall telecommunication subject through core concepts such as signals, transmission techniques, links, networks/services and market issues aiming at the students forming a well-structured overview of the telecommunication subject. At a second level, map elements were correlated to illustrate essential features of specific telecommunication applications. Kahoot, on the other hand, was used to help students visualize specific complicated topics such as electromagnetic propagation and signal transmission through optical fibers, the rationale being that visualization would help the students better comprehend the subsequent mathematical analysis. Kahoot was also used by the students to self-check the knowledge obtained by means of concept maps. The described approach was applied in the framework of telecommunication courses at the Department of Electrical & Electronic Engineering Educators, School of Pedagogical & Technological Education (ASPETE), Athens, Greece with the aim the students to develop technological and pedagogical content knowledge in accordance with the TPACK framework. The teaching process was evaluated through of two short questionnaires, the answer to which showed that the applied approach was successful and well received.

Chapter 26: *Enhancing motivation in dentistry education through an interdisciplinary multimedia project-based learning approach*; by Riánsares Arriazu Navarro, Encarnación Amusquivar Arias, Carlos Bocos de Prada, María José Borrego Gutiérrez, Lucía Guerra Menéndez, Elisa Jiménez Cabré, Esther Lantero Bringas, Úrsula Muñoz Morón, María del Nogal Ávila, María Isabel Panadero Antón, Sergio Portal Núñez, & Julio Sevillano Fernández. In recent years, fostering active student engagement and interdisciplinary learning in health sciences education has become increasingly important. This chapter presents an in-depth evaluation of the BioFilm project, an innovative Project-Based Learning initiative implemented with first-year Dentistry students at Universidad San Pablo-CEU, including both international and national students. Many dentistry students do not perceive the relevance of basic science subjects in their future profession, which can make learning process overwhelming. The BioFilm project was designed to bridge this gap by integrating Biology, Genetics, Biochemistry, and Physiology through collaborative didactic video creation. This approach promotes knowledge integration, encourages transferable skills development, and leverages Information and Communication Technologies (ICT) to enhance motivation. Drawing on the pilot project experience, this chapter offers a comprehensive analysis of its design, outcomes, and reflections from both students and faculty, highlighting key challenges and outlining recommendations for future implementation.

Chapter 27: *Embodied learning through approaching works of art in the education of future kindergarten teachers*; by Kalliopi Trouli & Sofia Trouli. This paper aims to explore embodied learning through approaching works of art in the context of educating future kindergarten teachers and to contribute to the application of contemporary theory of embodied cognition in Pedagogical Departments. The study highlights the pre-existing perceptions of future kindergarten teachers regarding the use of embodied learning through approaching works of art in the classroom or in a museum environment and proposes, based on students' concerns and needs, a workshop grounded in this approach. A two-phase mixed research study was conducted. In the first phase, 53 undergraduate students completed an initial questionnaire, followed by analysis of their responses. Based on the findings, a four-phase workshop was designed and implemented, simulating experiential embodied learning practices for the school classroom. In the second phase, 23 students from the initial sample participated in the workshop and completed a second questionnaire. Data were analyzed using descriptive statistics and thematic analysis. Findings from the first phase indicate that future kindergarten teachers associate artistic, physical, and cultural experiences with key aspects of comprehensive preschool development. Reflections from the second phase revealed deeper emotional engagement's motor activation, empathy, creativity, and participation in learning, highlighting the workshop's potential in teacher education.

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Section 1

Teachers and Students

Chapter # 1

THE USE OF AHARON APPELFELD'S *ADAM AND THOMAS* IN LITERARY EDUCATION

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ABSTRACT

This paper analyses the pedagogical potential of Aharon Appelfeld's *Adam and Thomas* (2013) for Literary Education and specifies implementation across three schooling levels: early primary, lower secondary, and upper secondary. Using qualitative literary content analysis, we evaluate the novel against explicit criteria: (1) developmental fit (linguistic demands, cognitive load, scaffolding); (2) thematic accessibility and complexity; (3) ethical and historical sensitivity when teaching traumatic literature, particularly Holocaust-related content; and (4) curricular alignment with reading comprehension, literary concepts, intercultural competence, and values education. We conceptualise the text's "spaces of indeterminacy" as structured invitations for learner interpretation, drawing on a reader-response perspective that acknowledges diverse cultural and historical backgrounds. Although the Second World War provides the setting, the narrative foregrounds agency, care, and moral growth, offering entry points for plot oriented as well as philosophically inclined students. We model grade-banded adaptations of the same passage to show progression in task complexity and sensitivity, and we outline safeguards (pre-teaching of context and vocabulary, informed choice, and debrief routines). The study provides transparent criteria and concrete pathways for age-appropriate classroom integration.

Keywords: Aharon Appelfeld, *Adam and Thomas*, literary education, content analysis, reader-response, Holocaust education

1. INTRODUCTION

"We will be able to talk about what we went through in the forest years later."
(Appelfeld, 2014, p. 108)

This chapter investigates the pedagogical potential of Aharon Appelfeld's *Adam and Thomas* (2013) and specifies how it can be integrated into Literary Education at three schooling levels - early primary (Year 1), lower secondary, and upper secondary. We selected this text because it offers multiple, developmentally varied points of entry: for younger pupils, an engaging survival narrative with clear plot lines and relational care; for more experienced readers, philosophical and ethical questions concerning faith, agency, responsibility, and the making of meaning after rupture.

Our approach is grounded in qualitative literary content analysis and a reader-response perspective. We treat the novel's well-known "spaces of indeterminacy" as intentional invitations for learners to co-construct meaning, while also attending to differences in cultural and historical knowledge. To support methodological transparency, we evaluate the text using explicit criteria - developmental fit, thematic accessibility/complexity, ethical and historical sensitivity (with particular attention to Holocaust-related content), and curricular

alignment - operationalised in the Methods section and applied in the analysis through grade-banded tasks that adapt a single passage across levels.

Appelfeld's oeuvre emerges from lived catastrophe. Born in 1932 in what is now Ukraine, he survived the Holocaust; his writing persistently explores trauma, loss, and the afterlives of violence. Scholarship highlights his focus on the impossible mourning of his murdered mother and the inscription of suffering on the body (Bannasch, 2023; Xia, 2024). Critics further note the tension his work stages between Jewish diasporic pasts and a Zionist present, blending fiction with autobiographical resonances to interrogate memory and identity (Coppel-Batsch, 2005). Langer (1995) underscores Appelfeld's poetics of the unsaid - avoidance, silence, and portent - which invites readers to infer historical horror without sensationalising it. His protagonists often grapple with reconciling past and present, a dynamic that resonates with survivor experiences within Israeli society (Shillony, 2014). Through spare yet evocative narration, Appelfeld preserves the cultural-historical episteme of Central European Jewry, illuminating how the Holocaust continues to shape individual and collective memory (Krausz, 2011).

In line with trauma-informed practice, we frame the Second World War as the historical setting rather than the spectacle of instruction. Classroom work is structured to maintain psychological safety: preparatory context and vocabulary, clear learning intentions, opt-in participation, and debrief routines. This enables age-appropriate engagement with ethical complexity without overwhelming learners, and it foregrounds care, solidarity, and moral growth as central interpretive threads.

The paper (i) situates *Adam and Thomas* within debates on teaching traumatic literature; (ii) articulates criteria for level-appropriate use; and (iii) demonstrates progression via adaptations of one passage across Year 1, lower-secondary, and upper-secondary classrooms. We conclude with practical guidance and considerations for inclusive facilitation.

Research questions:

1. RQ1: What literary features of *Adam and Thomas* afford age-appropriate engagement at different schooling levels?
2. RQ2: How can reader-response structures leverage indeterminacy while accommodating diverse cultural and historical backgrounds?
3. RQ3: What safeguards and scaffolds support ethically responsible discussion of Holocaust-related content in literature lessons?

1.1. Shortly about Book *Adam and Thomas*

Appelfeld's *Adam and Thomas* is best approached not as a direct memoir but as a literary reworking of experiences and imaginaries shaped by the Holocaust (Shoah). The Second World War functions as a historical backdrop rather than the explicit subject: a setting that confers moral gravity while allowing the author to probe affect, memory, and ethical commitment through understatement. This stance is consistent with Appelfeld's poetics of implication, in which silence, inference, and the unsaid invite readers to participate in making meaning rather than confront graphic depictions of atrocity.

The primary storyline is deliberately simple. Two Jewish boys, Adam and Thomas, are taken by their mothers into the forest in the hope of survival. During their concealment, they discover that Mina - a girl they know - has been hidden by a nearby farmer whose land borders the boys' makeshift shelter. The narrative concludes on a note of cautious consolation: Adam and Thomas are reunited with their mothers, and Mina - who has lost her family - is adopted. This clarity of action, focused on resourcefulness, friendship, and care, sustains engagement while avoiding sensationalism.

Such a pared-back plot affords age-appropriate entry points across cohorts. Beginning readers, many of whom may have little prior knowledge of the Second World War, can follow the text as an adventure of children in the woods, attending to problem-solving, mutual support, and hope. As Lobel (1998) notes, stories filtered through children's immediate experience can render complex events comprehensible to novices. For more experienced readers, the same scenes sustain discussion of transcendence, agency, trust, and responsibility, enabling progressively richer interpretation. To align with trauma-informed practice, classroom work should frame the war as context rather than spectacle, introducing historical background gradually and with care. Practical safeguards include pre-teaching key vocabulary and context, offering informed choices about participation, employing reflective and dialogic reader-response activities that acknowledge diverse cultural and historical backgrounds, and building in debrief routines. In this way, the novel's "spaces of indeterminacy" become structured invitations for learners to explore ethical complexity without being overwhelmed, while teachers maintain psychological safety and developmental fit.

1.1.1. Implementation of Philosophical Ideas

Beyond its pared-back adventure plot, *Adam and Thomas* stages a sustained meditation on faith, doubt, and pragmatic survival, allowing readers to consider the meaning of life, the (non-)existence of God, and the human place in a damaged world. These philosophically inflected passages - while not required for a basic grasp of events - offer fertile ground for reader-response work that acknowledges diverse cultural and historical backgrounds and invites pupils to test interpretations against textual evidence. For younger learners (early primary, Year 1), the focus can remain on ethical dispositions embodied in action - care, trust, and mutual aid - supported by teacher-led questioning such as: "What helps the characters keep going?" and "How do they look after one another?" At lower-secondary level, the same moments can open structured dialogues on practical wisdom versus belief (e.g., "What do the boys trust when food is scarce - skills, other people, or something beyond themselves?"), with short reflective journalling to surface multiple viewpoints. In upper-secondary classes, learners can interrogate the text's spaces of indeterminacy directly, contrasting pragmatic reasoning with the language of transcendence, and composing brief position papers that articulate and defend an interpretation using close quotation and contextual knowledge.

To ensure trauma-informed practice, the Second World War remains the historical setting rather than the spectacle: teachers pre-teach essential vocabulary and context, offer informed choice in participation, and provide debrief routines that normalise mixed emotional responses. Assessment across levels can be aligned with transparent criteria used in this study - developmental fit, thematic accessibility/complexity, ethical and historical sensitivity, and curricular alignment - for example, by evidencing comprehension (retelling or sequencing at primary), dialogic reasoning (accountable talk at lower secondary), and argumentation grounded in textual analysis (upper secondary). In this way, Appelfeld's philosophical layer becomes teachable without presupposing prior theological knowledge: younger pupils encounter ethical meaning through character and action; adolescents practise balancing pragmatic problem-solving with metaphysical questioning; and older students develop disciplined literary inquiry that links interpretation to historical awareness and civic reflection. Consequently, the text serves as a robust vehicle for Literary Education at multiple stages while modelling safe, age-appropriate engagement with Holocaust-related literature.

2. LITERARY EDUCATION AND PRESENTATION OF THE EVENTS OF WORLD WAR II

Literary Education offers distinctive affordances for introducing pupils to the Holocaust and the Second World War by combining narrative engagement with disciplined interpretative practice. As Bélanger (2024) argues, historical fiction can help young readers interrogate what literature reveals and what it withholds, thus cultivating a critical stance essential for grappling with the Holocaust's complexity. Literature also humanises history: by shaping personal experience into shared cultural forms, it enables new generations to encounter survivors' and victims' voices with ethical attention. In curriculum theory, memory and representation are not ancillary but constitutive; both historiography and the novel function as mediated memory that teachers must navigate with care (Morris, 2001). In parallel, cross-national pedagogical reforms increasingly foreground the Holocaust to counter hatred and intolerance, while adapting approaches to local cultural-political contexts (Schurster & Ramos, 2024).

2.1. Pedagogical Principles: Accuracy, Affect, and Agency

A central challenge is balancing historical accuracy with emotional engagement. Texts should not replace history but open routes into it. We therefore adopt four principles that align with the criteria used in this study:

- (1) Developmental fit: Select and scaffold texts so that language, cognitive demand, and themes are age appropriate.
- (2) Thematic accessibility/complexity: Begin with concrete experiences (friendship, care, resourcefulness) and build towards ethical and philosophical questions.
- (3) Ethical and historical sensitivity: Treat traumatic content with caution; centre dignity rather than spectacle.
- (4) Curricular alignment: Tie literary work to comprehension, interpretative strategies, intercultural competence, and values education.

In practice, literature lessons should contextualise narrative with concise historical framing, avoid sensationalised scenes, and include opt-in participation and debrief routines. Reader-response structures (think-aloud, reflective journals, structured dialogues) allow pupils to articulate interpretations while teachers monitor affective load and misconceptions.

2.2. Methods and Media: From Close Reading to Digital Storytelling

Alongside close reading, multimodal tasks can deepen understanding without diluting rigour. Carefully curated digital storytelling - e.g., short student-created audio narratives anchored in textual quotation and a verified historical detail - helps connect micro-stories to macro-history. Timelines, maps, and artefact galleries (constructed from approved resources) can be used to triangulate a scene from the novel with historical context, reinforcing accuracy while sustaining empathy. Such activities should include explicit source-evaluation prompts ("What does the text show? What must we verify historically? What remains uncertain?"), echoing Bélanger's (2024) emphasis on reading both revelations and omissions.

2.3. Attending to Diversity and Inclusion

Classrooms are culturally and historically diverse. Reader-response work should invite multiple perspectives while protecting students from presumption or disclosure pressure. Strategies include anonymous exit cards to surface questions, choice of modalities (writing, drawing, audio), pre-teaching vocabulary for newcomers, and small-group protocols that normalise "passing" on contributions. These moves recognise differing prior knowledge and personal proximity to trauma, aligning with trauma-informed practice.

2.4. Positioning *Adam and Thomas* within a Teaching Repertoire

Adam and Thomas complement, rather than replaces, other well-used texts in Holocaust education. For younger cohorts, it offers a clear, non-sensationalised plot through which to explore care, trust, and problem-solving, before extending to carefully framed context. At lower-secondary, its “spaces of indeterminacy” support dialogic enquiry into practical wisdom, dependence, and responsibility. At upper-secondary, the same passages sustain argumentation about inference, silence, and transcendence, and can be paired with non-fiction excerpts or survivor testimony to corroborate or complicate literary impressions. Comparative work with established classroom texts (e.g., age-appropriate historical fiction or testimony) can highlight how different genres handle voice, focalisation, and ethical distance, thereby making visible the trade-offs between emotional immediacy and historical precision often debated in the field.

2.5. Assessment and Safeguards

Assessment should evidence both understanding and ethical engagement. At early primary, focus on retelling, sequencing, and vocabulary linked to care and cooperation. At lower-secondary, prioritise accountable talk and short reflections that distinguish textual evidence from background inference. At upper-secondary, use argumentative mini-essays that mobilise quotation, contextual knowledge, and counterargument. Across levels, maintain safeguards: advance notice of sensitive content, clear learning intentions, opt-in alternatives, and structured debriefs. These measures uphold accuracy and dignity while enabling age-appropriate, critical engagement with the Holocaust through literature.

3. RESEARCH METHOD

This study employs qualitative literary content analysis to examine the pedagogical affordances of Aharon Appelfeld's *Adam and Thomas* (2013) for Literary Education across three schooling levels (early primary/Year 1, lower secondary, upper secondary). Content analysis is well suited to educational inquiry because it systematically identifies patterns of meaning and thematic structures beyond surface features, addressing the limits of impressionistic evaluation (Bingke et al., 2022). Thematic content analysis, in particular, foregrounds latent themes and value-laden motifs rather than frequencies alone (Vimal, 2021); in an educational precedent, Anagaw (2020) shows how content analysis can reveal the distribution of civic virtues and skills across curricular materials, underscoring its promise for assessing the instructional value of literary texts.

Our design integrates two complementary lenses: a thematic analysis that traces motifs (e.g., care, agency, responsibility, faith/doubt, resourcefulness) and structural features (e.g., focalisation, silence, “spaces of indeterminacy”); and a reader-response perspective that anticipates varied receptions among pupils with different cultural and historical backgrounds and translates textual affordances into level-appropriate tasks. The corpus comprises the English translation of *Adam and Thomas* (2013/2014); the units of analysis are scenes, narrative turns (problem–response–consequence), and short quoted passages that condense a motif or ethical dilemma.

To ensure methodological transparency, each unit was evaluated against four criteria aligned with our educational aims: developmental fit (linguistic demands, cognitive load, scaffolding potential), thematic accessibility/complexity (concrete entry points for younger pupils and layered meanings for older students), ethical and historical sensitivity (risk of distress, need for preparatory context, suitability for trauma-informed teaching of Holocaust-related content), and curricular alignment (links to reading comprehension,

literary concepts - characterisation, focalisation, symbolism - intercultural competence, and values education). Each criterion was rated on a three-point descriptive scale (emerging/appropriate/advanced) with brief analytic justifications to preserve qualitative depth. The procedure unfolded in three stages: open coding (inductive memoing of motifs, narrative functions, and pedagogical affordances at scene level); axial coding (grouping codes under the four criteria and mapping tensions such as ethical sensitivity versus task complexity); and pedagogical modelling (deriving grade-banded adaptations of the same passage - Year 1, lower secondary, upper secondary - to demonstrate progression in interpretative demand and affective safeguards).

Trustworthiness was enhanced through analytic memos, code–passage matrices, and peer debrief (a second reader audited a sample of coded units and challenged interpretations); dependability was supported by an audit trail documenting code changes and criteria applications; confirmability was pursued via reflexive notes on the researchers' positionalities (literature/education backgrounds) and their potential influence on theme selection. Where disagreements arose (e.g., on the suitability of a scene for early primary), they were resolved by specifying additional scaffolds or deferring the passage to an older grade band. Because the novel intersects with Holocaust history, all pedagogical recommendations are framed by trauma-informed practice: advance notice of sensitive content, pre-teaching of context and vocabulary, opt-in participation with alternatives, and structured debrief routines; historical framing is concise and age-appropriate, with the war treated as context rather than spectacle. As a text-centred analysis, our findings concern pedagogical potential rather than measured learning outcomes; classroom trials, learner feedback, and cross-cultural replications are needed to test transferability. Nevertheless, by making criteria, coding, and safeguards explicit, the method provides a transparent basis for integrating *Adam and Thomas* into literature classrooms at different educational stages.

4. IMPLEMENTING ADAM AND THOMAS ACROSS SCHOOLING LEVELS

In this section, we translate the above theoretical and methodological framing into level-specific pathways for classroom use. Our aim is to show how the same text can serve developmental fit, thematic accessibility/complexity, ethical and historical sensitivity, and curricular alignment across early primary (Year 1), lower secondary, and upper secondary.

4.1. Reception of the Primary Storyline

The novel introduces Adam with economical clarity: *Adam is nine years old and about to finish fourth grade... This made his parents happy, and they bought me a new soccer ball* (Appelfeld, 2014, p. 8). Thomas is sketched in sharper, scholastic relief: conscientious, academically strong, yet socially marginalised - *it was these efforts that compounded the hostility towards him* (p. 16). As foils, Adam and Thomas orient readers to contrasting dispositions that later inflect responses to faith, risk, and care. Character contrast is a well-established motivator for reader engagement (Alexandre, 2008) and can scaffold differentiated identification: pupils may *find themselves* in one boy's outlook while remaining curious about the other. In religious–moral character education, such contrasts offer accessible conduits to ethical inquiry (Efendi, Amelia, & Hayati, 2019).

Family backgrounds further deepen these profiles. Thomas's parents are teachers who valorise learning - *Education protects us... We must take care of the soul* (Appelfeld, 2014, pp. 22–23) - which frames Thomas's tendency to reason and to borrow his father's cadences. Adam's ghetto labour - helping in a public kitchen, rationing bread and soup

(p. 23) - foregrounds practical care and responsibility. For beginning readers, these details stabilise the primary storyline - two boys surviving in the forest - without requiring uptake of the philosophical layer. For more experienced readers, the same details prompt questions about what sustains people under pressure: skill, solidarity, or something beyond the self.

4.1.1. Classroom Moves

1. Year 1: picture-supported character cards (likes/skills/help received/help given); simple sequencing of events; vocabulary pre-teaching (forest, shelter, share, help).
2. Lower secondary: Venn diagram comparing the boys' dispositions and strategies; short response journals (*What does each boy rely on when things are difficult?*).
3. Upper secondary: close reading of two brief passages (Adam's kitchen work; Thomas's father's dictum) to infer worldview; mini debate on *What protects us: knowledge, community, faith, or luck?*

Safeguards across levels include advance notice of sensitive content, opt-in alternatives for speaking, and debrief routines.

4.2. Philosophical Passages

Philosophically inflected moments extend the narrative's interpretative reach without carrying the plot. Consider Thomas's imagined exchange with his mother - *I forgive you.../ Do not forgive me easily...* (Appelfeld, 2014, p. 31) - or the dialogue about the forest and human predation: *Sometimes the forest is better than people... So, it follows that humans are far worse* (p. 57). Such passages align with scholarship on children's literature of the Second World War as a site for exploring trauma, displacement, responsibility, and ethical imagination through implication rather than spectacle (Wróblewski, 2024; Franco, 2021; Sainsbury, 2017; Krongold, 2020). Within the novel, two currents meet: one boy shaped by orthodoxy, the other by rational pragmatism. As the relationship matures, these currents enrich one another; neither is definitive or rigid.

4.2.1. Classroom Moves

1. Year 1: Think-pair-share on care and fairness (*What feels kind in this scene?*); role-play with sentence stems (*I can help by...*).
2. Lower secondary: structured dialogue contrasting pragmatic reasoning and trust/faith; exit cards capturing a lingering question or doubt.
3. Upper secondary: Socratic seminar on the ethics of forgiveness and judgement under duress; brief position papers using quotation and contextual knowledge to defend an interpretation of the *forest vs. humans'* exchange.

Trauma-informed pedagogy here means the war remains context, not spectacle; teachers pre-teach historical basics and vocabulary, monitor affect, and normalise passing or writing privately.

4.3. Pathways for Integration in Literary Education

The novel's layered design supports repeated returns across the school career, with new meanings emerging on re-reading. Because the Second World War is implicit rather than graphic, age-appropriate work with younger pupils is feasible when framing and safeguards are in place. Literature can sensitise without sensationalising: handled carefully, it helps children process difficult emotions and taboo topics in bounded ways (Ungeheuer-Gołąb, 2024). In this sense, *Adam and Thomas* exemplifies how Second World War literature can illuminate the human consequences of conflict and clarify ethical stakes without imposing trauma (Ben-Tovim, 2022).

4.3.1. Progression Model Using One Shared Passage

1. Year 1: Guided read-aloud with images; identify who helps whom; draw-and-label shelter items; formative check via retell/sequence.
2. Lower secondary: Perspective-taking diary entry (Adam vs. Thomas); source-spotting of what is told, what is hinted, what needs historical verification.
3. Upper secondary: Comparative analysis - the same passage alongside a short non-fiction extract or testimony; evaluate how focalisation and silence shape ethical distance; mini-essay with counterargument.

Assessment aligns with our criteria: comprehension and vocabulary (developmental fit), reasoned inference (thematic complexity), ethical self-monitoring and respectful discourse (sensitivity), and explicit links to literary concepts and citizenship aims (curricular alignment).

5. CONCLUSION AND DISCUSSION

This study has advanced a transparent, criteria-led framework for integrating Aharon Appelfeld's *Adam and Thomas* (2013) into Literary Education across early primary, lower secondary, and upper secondary classrooms, demonstrating how an accessible survival narrative, paired with a restrained philosophical layer, can sustain grade-banded adaptations that preserve psychological safety while cultivating increasingly sophisticated interpretation.

Our findings operationalise key theoretical strands: following Bélanger (2024), we turn the novel's *spaces of indeterminacy* into teachable moments that invite pupils to interrogate both revelation and omission; consistent with Morris's (2001) account of literature and historiography as mediated memory, our comparative tasks triangulate literary inference with historical verification, foregrounding how focalisation and silence shape ethical distance; in line with Krongold's (2020) observation that youth Holocaust narratives move from factual recounting towards metaphor, our close readings leverage implication without sacrificing accuracy; and, echoing Wróblewski (2024), Franco (2021), and Sainsbury (2017), we recast philosophically inflected passages as age-appropriate ethical enquiries - ranging from care and fairness in Year 1 to argumentation about judgement under duress in upper secondary.

The criteria we apply - developmental fit, thematic accessibility/complexity, ethical and historical sensitivity, and curricular alignment - offer a portable quality standard that can be adapted to local contexts in the spirit of Schurster & Ramos (2024), while our trauma-informed stance aligns with Ungeheuer-Gołąb's (2024) and Ben-Tovim's (2022) insistence on sensitisation without sensationalism.

Conceptually, the paper contributes a bridge from theory to practice by linking reader-response, memory studies, and ethics of representation to concrete classroom routines; methodologically, it replaces impressionistic text selection with a documented content-analytic protocol and descriptive ratings; pedagogically, it provides reusable task archetypes (shared-passage progression, comparative corroboration, structured dialogue) that support inclusion and dignity.

We acknowledge tensions between accuracy and affect, safety and challenge, and universality and specificity; these require careful teacher preparation and culturally responsive facilitation. As a text-centred inquiry, our conclusions speak to pedagogical potential rather than measured outcomes; future research should include classroom trials with learning and affective measures across diverse settings, and comparative studies pairing *Adam and Thomas* with other age-appropriate texts to examine how genre, focalisation, and ethical distance mediate understanding and empathy. By aligning theoretical insights with developmentally staged practice, this work offers a coherent route for using *Adam and Thomas* to humanise historical understanding and cultivate disciplined, compassionate literary enquiry.

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KEY TERMS & DEFINITIONS

Literary Education: Teaching and learning that develop pupils' literary understanding (e.g., interpretation, genre, form, ethics of reading) through sustained engagement with texts.

Holocaust education: Curriculum and pedagogy concerned with learning about the Nazi genocide, its histories and legacies, taught with historical accuracy and ethical sensitivity.

Second World War (as context): The historical setting against which a narrative unfolds; in this chapter, war is framed as context rather than spectacle.

Reader-response: A pedagogical and theoretical approach foregrounding learners' meaning-making, recognising diverse backgrounds, experiences, and affective responses.

Spaces of indeterminacy: Purposeful gaps, silences, or ambiguities in a text that invite inference and multiple interpretations.

Focalisation: The vantage point or perspective through which narrative information is filtered (e.g., a character's viewpoint).

Ethical distance: The degree of proximity a text creates between readers and represented suffering, shaping empathy without sensationalism.

Developmental fit: Alignment between task/text demands and learners' linguistic, cognitive, and socio-emotional readiness.

Thematic accessibility/complexity: The availability of concrete entry points for younger pupils and layered meanings for older students.

Ethical and historical sensitivity: Careful treatment of traumatic content (e.g., Holocaust-related material) to protect dignity and minimise harm.

Trauma-informed practice: Teaching that anticipates potential distress, offers choice, scaffolds context and vocabulary, and provides debrief routines.

Intercultural competence: The ability to engage respectfully with cultural difference, perspectives, and histories, including Jewish experience before, during, and after the Holocaust.

Values education: Structured opportunities to reflect on and practise dispositions such as care, responsibility, fairness, and solidarity.

Close reading: Slow, text-centred analysis of language, structure, and form to ground interpretation in evidence.

Dialogic teaching: Structured talk (e.g., seminars, accountable discussion) that elicits, connects, and extends pupil ideas.

Grade-banded adaptation: A single passage or task redesigned with progressive demands for early primary, lower secondary, and upper secondary cohorts.

Digital storytelling: Short, carefully curated audio/visual narratives created by students, anchored in textual quotation and verified historical detail.

Historical verification (triangulation): Corroborating literary inference with reliable historical sources (e.g., testimony, archives, scholarly summaries).

Opt-in participation: Participation by informed choice, allowing pupils to pass, write privately, or engage through alternative modalities.

Debrief routine: A planned reflective closure to process learning and emotions, clarify misconceptions, and signpost support if needed.

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Chapter # 2

INCLUSIVE STRATEGIES FOR THE TEACHING AND LEARNING OF QUEER-THEMED CURRICULA IN THE LANGUAGE CLASSROOM

A narrative review

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ABSTRACT

The global discussion surrounding the social challenges faced by queer identities and the incorporation of queer-inclusive curricula in educator training is extensive. Queer individuals encounter queerphobia in their daily lives, which engenders adverse experiences for queer students within heteronormative educational settings. The investigation into the inclusion of queer-themed curricula has yielded promising and beneficial outcomes. However, there remains a gap in implementing pedagogical strategies, as there appears to be a disjunction between the experience of queer individuals and their prerogative to human rights, specifically equality, within the language classroom. Consequently, there is a pressing need for further information to equip educators with the pedagogical knowledge required to integrate queer-themed curricula effectively into the language classroom. The qualitative approach, with social constructivism (as the research paradigm) and textual analysis (as the research method), makes up the research methodology of this chapter. The results highlighted and discussed strategies educators could implement in their teaching and learning to include queer-themed curricula: addressing heteronormativity, “leaning in” to discomfort, including intersectionality, reading “straight” texts through a “queer lens”, including texts with queer characters, queering queer-inclusive texts, analysing high-caliber queer literary elements (e.g., themes and characters), and creating safe zones.

Keywords: inclusive strategies, language classroom, pedagogical knowledge, queer-themed curricula, queer identities, queer theory, social constructivism.

1. INTRODUCTION

The purpose of this chapter is to explore inclusive strategies for teaching and learning queer-themed curricula within the language classroom. Firstly, it begins by outlining key background information on queer identities and the role of queer-themed curricula in language education, establishing the broader social and educational context in which this discussion is situated. Secondly, the chapter introduces queer theory as the guiding theoretical framework, clarifying how its principles inform the pedagogical arguments that follow. Thirdly, the chapter explains qualitative research, social constructivism, and textual analysis to ground the discussion methodologically. Building on this foundation, the chapter, fourthly, provides a range of inclusive strategies that language educators can adopt to integrate queer-themed curricula into their classrooms meaningfully. The chapter concludes by identifying key areas for future research, highlighting the ongoing need for scholarship that supports equitable, affirming, and contextually responsive language education.

2. BACKGROUND

Rennick (2015, pp. 83-84) articulates that queer individuals presently encounter a multitude of social, economic, and political challenges. Kosciw Clarks, and Menard (2022, p. xv) and Staley and Blackburn (2023) affirm that schools are “hostile environments” for many queer students concerning anti-queer discrimination, language, and victimisation, resulting in violent consequences. These challenges serve as significant reminders of the necessity of providing students in the twenty-first century with meaningful opportunities to interact critically with diverse global perspectives. Nzimande (2015) and Page (2017) posit that numerous educators aspire for students to experience safety, comfort, and respect in their academic environments. Establishing a positive academic environment for queer individuals is imperative, transcending the scope of programmes solely focused on anti-bullying. Curricula inherently reflect the values and individuals esteemed within education settings; therefore, for sexual orientations and gender identities (i.e., queer identities) to be appreciated and/or accepted by students, it is essential for educators also to accept, appreciate, and embrace them, and not to have “a discourse of silence surrounding gender and sexual diversity in [...] schools and teacher education” (Staley & Blackburn, 2023, p. 1). Educators who demonstrate willingness to adapt curricula and address issues pertaining to queer identities significantly enrich their students’ educational experiences.

Glazzard and Stones (2021) claim that a queer curriculum aims to teach students the value of respect by legitimising queer identities that differ from the heteronormative norm. Students with non-normative orientations and identities run the risk of experiencing and being forced to deal with various types of victimisations, stigmatisation, and discrimination. Poklad (2025) reports that young queer individuals express that educational practitioners lack sufficient inclusive education training. Thus, educators might “require guidelines for selecting and teaching queer texts to their [students] since the content is sensitive” (Uys, 2020, p. 13). These guidelines pertain to contentious topics (such as rejection, queerphobia, heteronormativity, and privacy rights).

Accordingly, the research question for this chapter is: What inclusive strategies could educators consider and implement when teaching queer-themed curricula to create awareness and understanding of queer identities in their language classrooms? Language classrooms were specifically chosen due to all students receiving language education in one form or another, be it a home language, additional language, or foreign language. Language classrooms also focus on developing speaking, writing, reading, and listening as skills, which could be done by considering and implementing various topics and themes (Alhaider, 2023; Malindi, Ndebele, & Gobingca, 2023; Ye & Xu, 2023; Yin et al., 2022), such as queer identities (Uys, 2023).

Despite the possession of their own repertoire of effective and legitimate inclusive strategies, this chapter provides educators with a collection of additional queer-specific inclusive strategies that can facilitate the selection, teaching, and learning of queer-themed curricula. An example of a queer-themed curriculum can be viewed on pages 265-271 of Uys, M. J. (2023). *Inclusion of queer literature in a School for Language Education at a university: A framework* (Doctoral thesis).

The theoretical framework that underpins this chapter is Queer Theory.

3. THEORETICAL FRAMEWORK

3.1. Queer Theory

Queer Theory encompasses a constellation of critiques arising from a rich heritage of activism, while anticipating utopian futures (Acadia, 2021). Manning (2016) posits that Queer Theory does not constitute a singular theoretical perspective or a definitive set of propositions concerning gender and sexuality. Instead, it encompasses a multidisciplinary and heterogeneous array of influences, methodologies, inquiries, and frameworks that engage with numerous and sometimes conflicting viewpoints regarding sex and gender, serving as an analytical tool for interrogating power and power dynamics. Consequently, gendered and sexualised practices, which are deemed deviant within heteronormative contexts, are subject to exploration. Acadia (2021) articulates that Queer Theory functions as a mechanism for penetrating beneath superficial layers and endorsing unconventional interpretations that deconstruct normative assumptions. In the realm of education, there is an increasing interest in rendering teaching practices more inclusive of queer individuals and issues (Nelson, 2008). Thus, Queer Theory facilitates innovative and novel interpretations of both the living world and texts (Acadia, 2021).

The methodology for this chapter entails a qualitative approach, social constructivism, and textual analysis.

4. METHODOLOGY

4.1. Qualitative Approach

Given (2008) elucidates that the exploration of novel phenomena typically employs the qualitative approach to encapsulate an individual's interpretations, feelings, and/or thoughts of processes and meanings. Strydom (2005) further expounds that non-human participant observation entails gathering data using a qualitative approach, which is typically impossible to quantify. Additionally, the qualitative approach assumes that a single researcher may gain a valid understanding of the material through experience.

Given (2008) further explains, however, that a researcher employing a qualitative approach recognise that the study and its objects cannot be fully understood in an objective or unbiased manner since they are both complicated and subject to change. Consequently, the researcher is invariably intertwined with their research, as the interaction between the observer and the observed constitutes a fundamental component of research.

Accordingly, the qualitative approach was applied in this chapter by interpreting scholarly texts and educational phenomena to generate a rich, descriptive, and context-dependent understanding of queer inclusive strategies for language education.

4.2. Social Constructivism

Social constructivism is a vague and ambiguous philosophical paradigm in which researchers do not always determine what is generally accepted as right or wrong, good or bad, true or false. Consequently, this paradigm emphasises relational dynamics and upholds the role of the individual in the social construction of realities. Moreover, this perspective posits the existence of multiple truths and realities throughout the research process. Rather than aiming to create something, this philosophical paradigm exerts influence on the processes that facilitate formation (Galbin, 2014). It posits that all knowledge has been influenced or shaped by relationships with language, ideologies, religious beliefs, politics, and values (Given, 2008). Subsequently, individuals create their own realities based on their

views of the real world, and all constructions within the same universe are, therefore, different. Accordingly, language and communication are crucial to the interactive process by which people understand the world and themselves (Galbin, 2014).

Hence, social constructivism was applied by analysing queer identities, heteronormativity, and classroom meaning-making as socially constructed phenomena, and by proposing pedagogical strategies that rely on collaborative interpretation and dialogue.

4.3. Textual Analysis

Textual analysis concentrates on written materials and their contributions to the phenomenon under investigation. Documents function as agents in the research process, exerting enduring effects, given their perpetual availability for the manipulation of allies, mobilisation of resources, and/or neutralisation of opponents. Essentially, documents (electronic or printed) exist perpetually and can be analysed for research to address any problems and phenomena (Nieuwenhuis, 2016; Given, 2008). Additionally, these documents can help create interpretations of a particular topic, whether they are positive or negative. Accordingly, documents are placed in a social context, considering the reasons behind the author's production and identifying the intended audience (Given, 2008).

For this reason, textual analysis was applied by examining academic, literary, and curriculum-related texts as data sources, interpreting their representations of queer identities and heteronormativity, and using those insights to provide inclusive pedagogical strategies.

4.4. Ethics

The North-West University granted permission for this study to be conducted, ethical clearance numbers being: NWU-01612-19-A2 and NWU-01053-21-A2.

5. FINDINGS AND DISCUSSION

The Oxford English Dictionary (2025) defines “strategy” as “a plan, scheme, or course of action designed to achieve a particular objective, esp. a long-term or overall aim”. Accordingly, the following discussion entails inclusive strategies (i.e., a plan) for queer-themed curricula in the language classroom to create awareness and understanding of queer individuals (i.e., a long-term, overall aim).

5.1. Addressing Heteronormativity

The strategic consideration and implementation of a “cross-disciplinary pedagogical intervention” to challenge and address heteronormativity may serve as an approach for educators aiming to integrate queer-themed texts into language classrooms (Poklad, 2025, p. 2). Blackburn and Smith (2010) explore this issue of heteronormativity in light of their concern regarding the limitations on queer-inclusivity. A significant portion of texts is produced from a heteronormative viewpoint, which may be interpreted as prioritising heterosexuality over queersexuality. In essence, queer-themed texts tend to be overlooked, which fosters prejudice. Rothmann and Simmonds (2015, p. 124) note that educators’ narratives “may exacerbate discursive discrimination and objectification towards [queer]sexual individuals as significantly different ‘other’”. To counteract this heteronormative bias of otherness, the researchers advocate for educational institutions to introduce specific initiatives that “sensitise [educators] to the nature of heteronormativity, which could potentially redress [queer]phobia in classroom contexts”. For elucidation, Cohen (2005, p. 24) explicated heteronormativity as the accumulation of institutions and practices

“that legitimizes and privileges heterosexuality and heterosexual relationships as fundamental and ‘natural’ within society”. Similarly, Blackburn and Smith (2010) justifiably challenge the notion that heterosexual orientation, merely one among many gender identities and sexual orientations, is a normative orientation. Heterosexuality becomes imperceptible when acknowledged as “normal”, thereby rendering other queer identities as anomalous or unconventional. Nevertheless, both heteronormativity and the straightness-as-normal concept are flawed. The insistence on “boys and men behave in masculine ways, including but not limited to being attracted to girls and women, and that girls and women behave in feminine ways, such as being attracted to boys and men, among other expectations of girls and women”, results in “egregious civil rights violations against queer individuals and imposes restrictions on straight women and men” (Blackburn & Smith, 2010, pp. 626-627). Therefore, other individuals should not be subjected to limitations because of the presumptions of others, addressing heteronormativity as a result.

5.2. “Leaning in” to Discomfort

The strategy of “leaning in” to discomfort should be contemplated and applied when teaching queer-themed curricula. Staley and Leonardi (2016) and Poklad (2025) articulate that educational literacy scholars have identified numerous methods by which language classrooms, especially those incorporating critical literacy and queer-inclusive practices, can confront heteronormativity and celebrate sexual and gender diversity that deviates from normalcy. Lin (2014) posits that educators ought to approach the teaching of queer-themed texts with the same strategies as they would employ for non-queer texts. Staley and Leonardi (2016) and Staley and Blackburn (2023) further expound that individuals who intentionally strive to embrace and advance through their discomfort are well-positioned to become effective advocates for queer individuals.

Discomfort manifests in various forms. Specifically, from the perspective of heterosexual individuals, they might simultaneously feel discomfort due to an unwillingness to engage with different queer identities because of their belief systems. Conversely, queer individuals encounter discomfort stemming from experiences of marginalisation. In this context, educators and students, who either merely tolerate or reject queer individuals and related topics (perceived as taboo, aberrant, or sinful), may retrospectively engage with these topics to cultivate a mindset potentially oriented towards acceptance or celebration, which is beneficial for the collective advancement of society. Thus, emotional discomfort must be taken into consideration when using queer interventions in language teaching. Addressing the dynamics inherent to heteronormativity and queerphobia requires a strategy of “leaning in” to discomfort, which is regarded as an innovative strategy.

Staley and Leonardi (2016, p. 218) discuss a noteworthy aspect in the discourse on queerphobia: the role of shock. The researchers observed that educators and students entering the language classroom often possess “less prior knowledge and awareness of gender and sexual diversity than the dedicated disruptors, which may have contributed to their initial emotional pain” – this suggests that both educators and students demonstrate a deficiency in their understanding of queer individuals. Those who experience shock and discomfort upon encountering victims of queerphobia in real-life scenarios may come to the realisation that their engagement with gender and sexual diversity has been minimal. This exposure can lead to an acknowledgement of their duty to safeguard queer individuals, even when such realities appear incongruous with their own beliefs. Furthermore, they may develop an implicit desire to avoid replicating “the egregiously homophobic responses of the [oppressed queer individuals] they read about” (Staley & Leonardi, 2016, p. 219). (Importantly, it must be noted that the exploration of queer identities does not inherently result in increased tolerance,

acceptance, or celebration, but may culminate in further rejection, particularly if an individual is unwilling to further their understanding of queer individuals.) Thus, Staley and Leonardi (2016) posit that experiences of discomfort and pain can serve as creative and essential components in the endeavour to confront and address queerphobia definitively. However, it is important to note that “leaning in” does not signify the eradication of all discomfort and pain. By “leaning in” to discomfort, individuals are encouraged to pursue rather than evade suffering, subsequently exploring the potential lessons derived from impassioned responses characterised by discomfort, fear, and emotional anguish. These experiences should not be regarded as wholly negative; rather, they can serve as catalysts for engaging critically with the dynamics of heteronormativity and queerphobia. In this context, “leaning in” emerges as a pedagogical strategy for educators aiming to prepare both students and themselves for the emotional labour of unlearning ingrained knowledge and advancing toward queer-inclusive and anti-oppressive transformation.

5.3. Including Intersectionality

Poklad (2025) found that queer individuals experienced intersectional epistemologies to be erased. Therefore, the incorporation of intersectionality can present a methodological strategy for the implementation of curricula focused on queer themes. Prior to engaging with intersectionality, an examination of both unitary and multi-unit approaches needs to be conducted.

Blackburn and Smith (2010, pp. 630-631) delineate that the unitary approach focuses “on a single category of difference and universalises the experiences of those” within that category. This approach asserts the dominance of “one category reigns paramount among others and is therefore justifiably the sole lens of analysis” (Hancock, 2007, p. 68). Consequently, there is no accommodation for alternative categories or analytical perspectives. Blackburn and Smith (2010) further elaborate that this methodology fosters competition among focus groups and fabricates an illusory sense of unity within them.

Conversely, the multi-unit approach is based on an additive paradigm where several categories proceed parallelly. Similar to the unitary strategy, it also promotes competition among focus groups. According to Hancock (2007, p. 71), intersectionality is posited as a remedy to the deficiencies inherent in both the unitary and multi-unit approaches. This concept seeks to address “questions left unanswered” by facilitating a fair analysis of several distinct categories, elucidating their interconnections. It aims to promote an understanding of the dialogical relationships between individuals and institutions, with an appreciation of both variety and hybridity within groups.

For instance, heterosexual and queer individuals exhibit differences in orientation and identities; however, individuals within both categories may adhere to religious beliefs or not, as an example. Blackburn and Miller (2017) assert that intersectionality identifies and highlights diverse, fluid representations of queer identities, thereby facilitating the incorporation of queer-themed curricula while recognising students’ multiple reflections of themselves, including portrayals of various identity roles. This strategy allows heterosexual students also to identify reflections of their own multifaceted identities or to observe a broader spectrum of queer identity representations. In addition to advocating for the experiences and equity of queer identities, the use of intersectional strategies encourages activities and discussions that aim to improve the lives of all oppressed individuals. Hence, Blackburn and Smith (2010) and Staley and Blackburn (2023) argue that encouraging and applying an intersectional strategy at the centre of discussions is valuable concerning literacy practices addressing issues significant to queer individuals. One viable approach to achieve this involves analysing who is excluded and the reasons for such exclusion; for example,

queer individuals may be marginalised due to religious beliefs. Thought-provoking narratives (that specifically examine sex, class, race, etc.) can work as catalysts for conversations about intersectionalities since they encourage readers to consider the intricacies that reside within identities. The fundamental idea is that individuals should be recognised for the different facets of their identities rather than only being classified as heterosexual or queer. These shared aspects could serve as a bridge to queer identities, rather than highlighting the divergent elements among them.

5.4. Reading “Straight” Texts Through a “Queer” Lens, Including Texts with Queer Characters, and Queering Queer-Inclusive Texts

As suggested by Hermann-Wilmarth and Ryan (2015) and Staley and Blackburn (2023), educators may develop pedagogical strategies to integrate queer-themed texts effectively into their teaching methodologies.

Subsequently, the practice of analysing “straight” texts through a queer perspective motivates educators to examine “straight” books – those without explicit queer characters – in a manner that, nevertheless, engages with themes of sexuality and gender. By critically analysing queer-themed texts that are already part of educators’ resources, the systems that normalise certain sexualities – while regarding others as deviations – can be scrutinised by examining how sexuality and gender are inherently present in conventional, non-queer writings. This approach is analogous to challenging heteronormativity. Thus, students can understand that these identities are not solely associated with queer individuals, but are rather fundamental components of how each individual moves through and lives in the world (Hermann-Wilmarth & Ryan, 2015). Blackburn and Miller (2017) describe this strategy as “reading queerly”. Educators can encourage students to question heteronormativity and queerphobia by fostering conversations about power and visibility. Essentially, literary texts are interpreted through a queer lens that concerns identity, discrimination, and equality, and queer-themed curricula are incorporated into language classrooms by taking a political stance. Even though openly acknowledged queer identities might not be frequently represented, educators can meaningfully enhance the experiences of their queer students by incorporating queer readings of texts that are already present in their classrooms and syllabi. Reading queerly offers educators a means to foreground queer identities in both their pedagogical practices and classroom texts. An example that could be highlighted in this context includes Dorian Grey in *The Picture of Dorian Grey*, authored in 1890 by Oscar Wilde, whose beauty is esteemed by other male characters.

An examination of queer characters in literary texts challenges the misconception that only heterosexual individuals populate both real-world and literary narratives. Consequently, this allows students to be exposed to diverse perspectives. Literary texts can be studied independently or integrated into subject-specific lessons and curricula delivered by educators, catalysing dialogue on tolerance, diversity appreciation, and the prevention of bullying. This strategy enables educators to engage with a broad spectrum of reading standards and proficiencies, including inferential reasoning and understanding authorial intent (Hermann-Wilmarth & Ryan, 2015). Instances of queer characters inhabiting heteronormative contexts include Albus Dumbledore and Gellert Grindelwald in J.K. Rowling’s *Fantastic Beasts* series (2016-2022), who are explicitly identified as homosexual, LeFou in Disney’s live-action adaptation, *Beauty and the Beast* (2017), and Gobber the Belch in *How to Train Your Dragon* (2010; 2025), where they are presumed and subsequently confirmed to be homosexual. Such representations invite educators and students to engage in discussions regarding the rationale for including queer characters within heteronormative frameworks.

Hermann-Wilmarth and Ryan (2015) propose a strategy termed “queering queer-inclusive texts” to address queer issues within literary works. This strategy involves the provision of texts, which are inherently queer inclusive from a queer perspective, to students. By applying a queer perspective to these queer-inclusive texts, one can highlight heteronormative narratives, enable readers to observe the intersection of alternative aspects of privilege associated with queer identities, and counteract prejudices of queer individuals perpetuated by traditional portrayals. Among these various examples of queer-themed texts, Brent Hartinger’s 2004 novel and 2013 film adaptation, *Geography Club*, Bill Konigsberg’s 2013 novel, *Openly Straight*, and Jeanette Winterson’s 1985 novel, *Oranges are not the Only Fruit*, are noteworthy. These literary works, which highlight the challenging experiences of queer individuals in heteronormative societies, are suitable for analysis in language classrooms (Uys, 2023).

5.5. Analysing High-caliber Queer Literary Elements (E.G., Themes and Characters)

An alternative strategy for the incorporation of queer-themed texts is advocated by Bacon (2016), Batchelor, Ramos, and Neiswanderet (2018), Blackburn, Clark, and Nemethet (2015), Cart and Jenkins (2006), Lord (2014), Sanders and Mathis (2012), and Poklad (2025). These researchers recommend that, in the selection of queer-themed texts for inclusion in language curricula, it is imperative to evaluate their content for elements – such as themes and characters – that necessitate recognition and dialogue about queer issues counteracting heteronormativity. The objective of engaging with queer-themed texts should not be merely to expose readers to additional perspectives, as mere interaction with literary works featuring queer characters does not inherently ensure that students will cultivate empathy for or an understanding of queer individuals. Rather, it is essential to recognise that incorporating these perspectives in texts presents an opportunity for comprehending queer identities and fostering empathy for queer characters and their experiences.

Themes as a literary element encompass topics such as displaying normalcy, family inclusion, the search for identity, stereotypes, queerphobia, prejudice and abuse, coming out, tolerance and acceptance, and religious zealotry (Sanders & Mathis, 2012; Uys, 2020). Accordingly, themes hold a pivotal role in texts. Engaging with texts can impart life lessons to students and assist them in connecting pedagogical content to real-life experiences. Through the lens of fictional characters or by indirectly experiencing the narratives of others, valuable insights can be attained. When students focus on themes, they start to assess the authors’ motivations for narrating these stories critically. Authors possess the liberty to explore themes, particularly because they resonate universally with individuals. Literary themes can serve as a mirror (for introspection) and a window (for gaining new perspectives) to aid readers in the development and affirmation of their identities. Heterosexual and queer readers alike can gain insights into the experiences of fictional queer characters within heteronormative environments by engaging with themes prevalent in queer-themed texts. Practically, these themes assist students in forging connections between a specific text, other texts, their experiential worlds, and the broader community, facilitating the combat against queerphobia and heteronormativity (Bacon, 2016; Batchelor et al., 2018; Lord, 2014).

Another literary aspect worth examining is the portrayal of fictional queer characters, which can be employed to confront analogous challenges, similar to how literary themes can be leveraged to address queer social issues within heteronormative societies. Characters are subjected to analysis and scrutiny concerning their universal depictions of physical appearances, actions, and personalities of a specific class or type (Drabble, 2000; Lutrin

& Pincus, 2020; Sutherland, 2011). Cart and Jenkins (2006) assert that there exist four distinct categories of fictional queer characters.

One such character is one who either voluntarily reveals or is involuntarily revealed as queer; this occurs when the character tells others around them that they are queer or when another character does so without their permission. An example of such a character is Jeanette in *Oranges are not the Only Fruit* (Winterson, 1985), as well as Russel in *Geography Club* (Hartinger, 2004; 2013).

Another type of character examines their queer identity within both non-queer and queer contexts; this category engages in various scenarios to determine their queer identity. Instances of this can be seen in Rafe from *Openly Straight* (Konigsberg, 2013), Jeanette from *Oranges are not the Only Fruit* (Winterson, 1985), and Russel from *Geography Club* (Hartinger, 2004; 2013).

A third category encompasses heteronormative contexts within non-queer texts that incorporate queer characters, exemplified by figures such as Albus Dumbledore, Gellert Grindelwald, LeFou, and Gobber the Belch. Another example is Ben in *Openly Straight* (Konigsberg, 2013).

The initial three categories of characters are typically prominent in queer-themed texts, whereas the fourth category is less commonly represented. Furthermore, scenarios or characters can be analysed from the perspective of fictional queer characters. Queer characters exhibit unique moral codes and worldviews. Conversely, another character's perspective can be employed to comprehend the queer character. By engaging with the queer character's struggles or witnessing the process of them coming out, readers can gain awareness of issues affecting queer communities globally. Through queer texts' evolution, their representations have become more nuanced and expansive. Characters that defy conventional expectations regarding queer behaviours and same-sex attraction have become increasingly prevalent, encompassing lesbian, gay, and bisexual individuals. Other characters may also challenge traditional gender norms by eschewing traits and behaviours typically correlated with the opposite gender to assert their gender identity, including transgender, non-binary, gender-fluid, and intersex individuals.

5.6. Creating Safe Zones

A supplementary strategy to consider in the pedagogy of queer-themed texts is the recommendation by Blackburn and Miller (2017, pp. 7-8) and Poklad (2025) to establish "safe zones". Students are prompted to identify correlations between literary texts and their personal experience, particularly about themes of discrimination, compassion, and equity. This approach facilitates dialogues on the establishment of "safe zones" – defined as environments in which individuals may articulate their perspectives without apprehension – in the classroom setting, while also encouraging students to endeavour towards reforms. While the classroom may not be completely devoid of insecurity, creating a sufficiently secure atmosphere can afford students the opportunity to be brave and engage with, analyse, and value queer-themed texts. This environment can significantly support numerous queer individuals who encounter adversarial conditions, fostering a sense of inclusion within the classroom. By integrating this approach, instructors can effectively mitigate heteronormative and queerphobic elements within language education, thereby cultivating a conducive space for students to engage in discourse on queer subjects. Additionally, this strategy may also serve to confront heteronormativity and queerphobia beyond the confines of the language classroom, as students can incorporate their learning into their daily lives in broader societal contexts. Kosciw et al. (2022) mention that queer students who experience safety and support at schools have better educational outcomes and experiences. It is, therefore, imperative to create safe and affirming learning environments.

6. FUTURE RESEARCH DIRECTIONS

To enrich the findings, empirical research could be conducted on educators implementing these inclusive queer-themed strategies and reflecting on their effectiveness to create awareness and understanding of queer identities in the language classroom, as this chapter only entailed a textual analysis (i.e., a narrative review), which could be considered a literature review for future empirical research.

7. CONCLUSION

Staley and Leonardi (2016) argue that heteronormativity fosters bullying, harassment, and other coercive enforcement methods, in addition to promoting queerphobia. Consequently, it is recommended that educational institutions critically address this heteronormative paradigm, equipping educators to affirm students' queer identities within the language classroom.

Inclusive strategies for the teaching and learning of queer-themed curricula, to create awareness and understanding of queer identities in the language classroom, have been provided in this chapter. The following are possible strategies educators may consider and implement:

- addressing heteronormativity;
- “leaning in” to discomfort;
- including intersectionality;
- reading “straight” texts through a “queer lens”;
- including texts with queer characters;
- queering queer-inclusive texts;
- analysing high-caliber queer literary elements (e.g., themes and characters); and
- creating safe zones.

Educators might require assistance in recognising the elusive yet powerful strategies in which queerphobia and heteronormativity shape their perceptions of appropriateness, should they aim to be inclusive concerning sexuality and gender. This recognition necessitates meticulous attentiveness to their pedagogical decisions and instructional strategies. Blackburn and Smith (2010, p. 625) elucidate that the incorporation of queer-themed curricula results in “patterns of acknowledgment (and subsequent astonishment) on the part of straight allies”. A limited number of individuals (such as educators and students) possess a comprehensive awareness of the extent of their involvement in queerphobia. Therefore, to address queerphobia both globally and in the language classroom, there is a requisite for a dedicated focus on developing anti-queerphobic strategies that are theoretical and practical, while concurrently supporting straight allies.

Concludingly, this chapter integrated queer theory into language education in a structured, pedagogically actionable way; it combined affective, cognitive, and analytical dimensions (e.g., discomfort, textual analysis, and intersectionality); it applied social constructivist principles to both research and teaching methodology; it operationalised textual analysis as a research and teaching tool; it provided concrete strategies and examples with global relevance; it expanded queer-inclusive pedagogy to emotional labour, safe zones, and ethical responsibility. As a result, the chapter's originality lies in its holistic, multi-dimensional, and practice-oriented approach to queer-inclusive language education, grounded in theory but explicitly actionable in language classrooms.

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KEY TERMS & DEFINITIONS

Queer identities: queer identities encompass a diverse range of sexual orientations (including lesbian, gay, bisexual, and other) as well as a spectrum of gender identities (such as transgender, non-binary, gender-fluid, and additional).

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Chapter # 3

UNLOCKING NATURAL ABILITY: EXPANDING OPPORTUNITIES FOR EMERGING PERFORMING ARTS ACTORS

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ABSTRACT

Natural talent makes the art industry richer with actors and performances. The study investigated the significance of creating opportunities for aspiring actors in the field of dramatic arts, emphasising the role of natural talent and structured training. The study adopts Howard Gardner's Theory of Multiple Intelligences as its theoretical framework. In the qualitative case study approach, twelve participants were purposively selected for the study. Data were collected through structured interview questions, which facilitated the identification of key themes through coding and thematic analysis. The findings reveal that, despite the significant challenges associated with pursuing an acting career, including intense competition and limited resources, various initiatives have emerged to support aspiring actors. Programs emphasising local theatre participation and community-based training provide essential skills and networking opportunities. The study recommends programs that prioritise raw talent and ensure accessibility in a supportive environment, where participants hone their artistic skills and develop critical life competencies, resilience, which could be essential for artists. The findings advocate for the expansion of similar initiatives that recognise and nurture natural talent in aspiring actors. The study concludes that there is a need to integrate performing arts education into community frameworks to cultivate future generations of artists.

Keywords: aspiring, creativity, dramatic arts, natural talent, opportunities.

1. INTRODUCTION

The development of talent in the dramatic arts has been a subject of considerable debate, with various models proposed to explain the emergence of successful actors, directors, and playwrights. Natural talent in the dramatic arts can be a powerful catalyst for aspiring actors, but it is often insufficient (Sparling, 2021). The journey toward a successful acting career requires not only innate ability but also the creation of opportunities that allow talent to flourish (Connell, Brown, & Baker, 2020). In today's competitive entertainment landscape, aspiring actors must navigate various pathways to gain experience and exposure. It may include engaging with local theatre groups, enrolling in acting classes, and participating in auditions for multiple productions (Sparling, 2021).

Moreover, the rise of digital platforms has revolutionised how actors showcase their skills (Connell et al., 2020). Many are now encouraged to create content through short films, web series, or social media performances. This proactive approach enhances visibility, allowing actors to define their artistic voice (Malafronte, 2021). As actors such as Issa Rae and Emma Stone have demonstrated, leveraging technology and creativity can lead to significant career breakthroughs (Lawal, Ibrahim, Ojodu, & Salvador, 2023). Ultimately, while natural talent is invaluable, the ability to seize opportunities and innovate within the industry truly empowers aspiring actors to succeed in the dramatic arts (Sparling, 2021).

These research questions guided the study:

1. How do aspiring actors perceive the role of natural talent in their journey towards success in the dramatic arts?
2. What opportunities do aspiring actors identify as crucial for developing their craft and advancing their careers in the dramatic arts?

2. BACKGROUND OF THE STUDY

The field of dramatic arts has long recognised natural talent as a cornerstone of artistic excellence; yet, aspiring actors in South Africa face significant barriers to realising their potential (Yende, 2025). Historically, access to training and performance opportunities remained limited, particularly in underserved regions like the Eastern Cape, where socioeconomic disparities and geographic isolation hindered talent development (Delpont, 2025). Formal theatre programs, often concentrated in urban centres such as Johannesburg and Cape Town, overlooked rural talents, perpetuating inequalities in the creative economy (Booyens, 2025).

Talent identification initiatives emerged sporadically in the early 2000s, driven by cultural festivals and community workshops, but these lacked systematic support (Ferreira, 2024). Aspiring actors relied on informal networks, self-taught skills, and sporadic auditions, resulting in high dropout rates and unfulfilled potential (Yende, 2025). Studies have documented how natural aptitude—manifested in innate expressiveness, emotional depth, and improvisational flair—fades without structured nurturing, thereby exacerbating unemployment among young people in the arts sector (Delpont, 2025). Government policies on the Sustainable Development Goals (SDGs), particularly SDG 4 (quality education) and SDG 8 (decent work), have highlighted the importance of inclusive and creative pathways (Monaco, 2024). It is worth noting that implementation gaps persist in nurturing natural talent within the dramatic arts education. The current study on natural talent, which creates opportunities for aspiring actors in the dramatic arts, addresses these challenges.

3. LITERATURE REVIEW

3.1. The Role of Natural Talent in Acting

Natural talent is often viewed as a foundational element in the acting profession (Connell, Brown, & Baker, 2020). While some individuals possess an innate ability to perform, this talent alone does not guarantee success (Malafronte, 2021). Research indicates that natural talent may be complemented by rigorous training and practice to develop the necessary skills for effective performance (Lawal et al., 2023). Actors such as Jennifer Lawrence have demonstrated that while raw talent can provide an initial advantage, continuous learning and adaptation are critical for long-term success in the industry (Malafronte, 2021). The integration of innate ability with structured training allows aspiring actors to cultivate these intelligences, thereby enhancing their craft. Furthermore, research suggests that acting is not solely reliant on innate talent, but rather on a complex interplay between genetic predispositions and environmental factors, such as rigorous coaching, role-playing, and networking opportunities (Kogan, 2002; Sparling, 2021). Importantly, access to community-based performing arts education creates pathways for marginalised groups by recognising and nurturing latent talent, contributing to cultural enrichment and career opportunities (Poth, 2023). Therefore, the development of natural talent requires ongoing effort, external support, and strategic opportunities to actualise success in the dramatic arts fully.

3.2. Creating Opportunities through Education and Networking

Education is pivotal in transforming natural talent into professional opportunities (Piirto, 2021). Aspiring actors benefit from formal training programs that teach essential skills such as text analysis, character development, and emotional expression (Plucker & Peters, 2020). Additionally, networking within the industry may be crucial; relationships with casting directors and fellow actors could lead to auditions and roles that might otherwise remain inaccessible (Mohamed Hashim, Tlemsani, & Matthews, 2022). Community theatre or workshops could also enhance visibility and provide practical experience (Lawal et al., 2023).

Markos (2024) emphasised that formal training cultivates versatility by exposing actors to diverse techniques, from classical methods to contemporary improvisation, enabling seamless adaptation across genres and character types. This structured environment fosters professional discipline, including punctuality, receptivity to direction, and ensemble collaboration, all of which are indispensable for sustaining a career (Swargiary, 2024). Workshops build confidence through repeated performance exercises, helping performers overcome stage fright and refine physicality, vocal projection, and emotional authenticity (Hu, 2024). Networking extends beyond casual connections; alum networks and faculty mentorship from training programs often yield endorsements, collaborations, and access to industry showcases attended by agents (Fisher & Price, 2021). According to Bukhari, Oladimeji, Etim, and Ajayi (2024), community initiatives further democratise opportunities by offering low-barrier entry points for skill-building and peer feedback, bridging gaps for underrepresented talents. Continuous education sustains competitiveness amid evolving industry demands, ensuring actors remain adaptable and resilient (Kucuksuleymanoglu, 2025).

3.3. The Importance of Continuous Development

Continuous personal and professional development is vital for aspiring actors (Jensen & Kim, 2020). The acting industry constantly evolves, and staying informed about industry trends, audition techniques, and performance styles is essential (Hagen, 2023). Actors could embrace lifelong learning through classes, workshops, and self-directed study to refine their craft and adapt to changing demands (Malafronte, 2021). The commitment enhances actors' skills and increases their chances of being noticed by casting directors, ultimately paving the way for successful careers in the dramatic arts (Piirto, 2021).

Markos (2024) highlighted that ongoing training sharpens versatility by introducing advanced methodologies, such as improvisation for spontaneity or voice modulation for diverse dialects, enabling performers to tackle multifaceted roles across film, theatre, and digital platforms. Self-directed practices, such as script analysis and monologue rehearsals, build resilience against rejection, fostering a growth mindset that views challenges as opportunities for refinement (Swargiary, 2025). Workshops simulate real-world pressures, honing ensemble dynamics and directorial responsiveness, which are critical for collaborative productions (Nedaei & Jacoby, 2025). Mentorship pairings with seasoned professionals offer insider insights into career navigation, from mastering self-taping to developing personal branding through social media (Laurin, 2024). This proactive approach combats skill stagnation during downtime, sustains passion amid irregular work, and positions actors as adaptable assets in a competitive landscape demanding innovation and emotional depth (Sahu & Bhattacharya, 2025).

3.4. Empirical Literature

This part outlined the empirical literature for the current study.

3.4.1. Genetic and Interactional Perspectives

The study by (Hatami, 2023) provides a foundational understanding of the genetic and interactional perspectives in the development of performing arts careers. (Campbell & Muncer, 2021) The developmental model considers both intrinsic and environmental determinants, while Simonton's model, based on Lykken's behaviour-genetic research, emphasised genetic factors. The suggestion that genetic factors may play a role, environmental influences and individual decisions are also critical in acting (Hatami, 2023) (Kogan, 2002a, b).

These frameworks highlight how genetic predispositions interact with nurture to shape performative aptitude, where innate traits such as emotional expressivity or spatial awareness emerge through practice and feedback (Campbell & Muncer, 2021). Twin studies reveal heritability estimates for creative and artistic abilities ranging from moderate to high, underscoring polygenic influences alongside shared family environments that foster early exposure to the arts (Dechaume, 2024). Individual agency manifests in deliberate skill-building, such as vocal training or improvisation drills, which amplify latent potentials (Dartey, 2021). Longitudinal research demonstrates that optimal talent trajectories arise from synergistic effects: genetic baselines provide raw capacity, while enriched contexts, mentorship, cultural immersion, and opportunity structures catalyse exceptional outcomes in dramatic arts careers (Oliver, 2025).

3.4.2. Environmental Influences and Opportunities

Environmental factors, such as access to quality training and mentorship, play a significant role in the development of aspiring actors (Cherian & Francis, 2021; Kearney & Levine, 2020). The heterogeneity in students' prior school and undergraduate experiences highlights the importance of providing diverse and inclusive opportunities for training in the dramatic arts (Subotnik, Olszewski-Kubilius, Khalid, & Finster, 2021). Programs that offer a range of experiences and support can help nurture talent from diverse backgrounds, ensuring that natural talent is not the sole determinant of success (Malafronte, 2021).

Such programs counteract socioeconomic barriers by offering scholarships, outreach initiatives, and flexible scheduling that accommodate diverse learners from rural or urban settings (Ray & Chakravarty, 2025). Mentorship fosters personalised growth through guidance on portfolio development, audition preparation, and resilience-building in the face of industry rejection (Chaiwanichsiri, 2024). Family and community support systems further amplify opportunities by encouraging early arts exposure, such as local theatre involvement or cultural festivals, which build foundational confidence and networks (Schnyder, Wico, & Huber, 2021). (Kearney & Levine, 2020) highlighted that school environments enriched with drama clubs or interdisciplinary collaborations enhance performative skills alongside academic pursuits. These layered influences create equitable pathways, transforming potential into proficiency and enabling underrepresented actors to compete effectively in professional arenas (Mergen & Güven, 2025).

4. THEORETICAL FRAMEWORK

Howard Gardner's theory of multiple intelligences serves as a framework for understanding talent in the dramatic arts (McClellan & Conti, 2008). It identifies distinct intelligences, particularly interpersonal and bodily-kinesthetic, crucial for acting

(Şuruba-Rusen, Murăreţu, Murăreţu, Petre, & Teodoru, 2020). Interpersonal intelligence aids authentic character portrayal, while bodily-kinesthetic intelligence supports physical expression (Lawal et al., 2023). The theory suggests that actors can enhance their skills through targeted training (Chew & Mohamed Zainal, 2024) and promotes inclusive programs that recognise varied strengths, addressing equity gaps (O'Dell, 2025). Neuroimaging links specific brain networks to these intelligences, reflecting acting requirements (Bekkali, 2019). Gardner emphasises cultural context in nurturing potential, informing workshops that develop diverse abilities (Gardner, 2024).

5. METHODOLOGY

A qualitative research approach was employed to explore the complexities of acting talent and the opportunities available to aspiring actors (Maxwell, 2021). The method captures individual experiences, revealing how innate abilities interact with training and networks (Dartey, 2021), while uncovering barriers faced by individuals from diverse backgrounds, thereby informing inclusive frameworks (Dechaume, 2024). It is worth noting that factors such as ethnicity, socioeconomic status, and location can marginalise aspiring actors (Mkwanzani & Melis Cin, 2020), thereby affecting their access to auditions and training. The research promotes equitable landscapes in the performing arts (Collins et al., 2022) and emphasises ethical considerations to ensure participant safety (Kearney & Levine, 2020). By understanding individual experiences and systemic influences (Delpont, 2025). Stakeholders could work towards dismantling barriers and fostering a more inclusive acting industry (Kearney & Levine, 2020).

5.1. Data Collection and Analysis

Open-ended interviews were used to collect data, allowing participants to share rich narratives about their motivations for pursuing acting careers (Maxwell, 2021). The qualitative approach provided insights into the emotional and psychological aspects of acting (Hoemann et al., 2024). The unrestricted format enabled actors to express themselves freely, resulting in more nuanced narratives and a deeper understanding of their experiences (Kahl, 2019). Thematic analysis revealed both external factors, such as family support and education, and internal struggles, including self-doubt and the search for validation (Maxwell, 2021). Participants described their training as rigorous yet transformative, influencing their identities (Hatami, 2023). Many found acting to be a therapeutic outlet for exploring complex emotions, highlighting the balance between creative joy and mental health challenges (O'Dell, 2025).

5.2. Research Design

A case study was employed to investigate individual experiences within the acting community. The qualitative approach focused on specific actors or acting schools, revealing how natural talent interacts with opportunities in the dramatic arts (Poth, 2023). Through interviews and observations, the study highlighted the influence of mentorship, training, and networking on artistic development (Maxwell, 2021). It captured the diverse backgrounds of actors and offered insights for educators and aspiring actors (Oliver, 2025). The findings can inform best practices and foster a more inclusive environment for emerging talent (Schnyder et al., 2021). The case study approach enhances understanding of the talent-opportunity relationship in the dramatic arts, paving the way for future research and applications (Hoemann et al., 2024).

5.3. Population and Sampling

The study employed purposive sampling with twelve actors to gain insights into the dramatic arts and the role of natural talent in career trajectories. This qualitative approach enables the selection of participants with relevant experiences, thereby enhancing the credibility of the findings (Poth, 2023). While prior research acknowledges the importance of natural talent, it often overlooks its interaction with training and other factors (Connell et al., 2020). Through in-depth interviews, the study captures the complexities of each actor's journey (Hatami, 2023), which is vital for understanding the multifaceted nature of the human experience in the arts (Poth, 2023). Ultimately, the research highlights the role of natural talent in shaping career paths, offering valuable insights for practitioners and educators (Maxwell, 2021).

5.4. Data Collection

Data collection for the study was conducted using a structured interview. The method was chosen for its efficiency in gathering comprehensive data and analysing trends and patterns related to talent perception and opportunity identification among aspiring actors (Poth, 2023). The interview questions consisted of both closed-ended and open-ended questions. Closed-ended questions provided quantifiable data, enabling researchers to assess the prevalence of certain beliefs about natural talent and the types of opportunities actors consider most beneficial (Creswell, 1999). The interview tool was distributed online to reach a diverse group of aspiring actors across different backgrounds and locations.

5.5. Data Treatment and Analysis

Qualitative data from open-ended questions were thematically analysed, focusing on talent development and opportunity creation. Thematic maps illustrated how aspiring actors navigate their careers, revealing the complex interplay between individual talent and external factors. Themes included mentorship, access to resources, and networking, all of which are vital for career advancement. The study also highlights the significance of resilience and adaptability in a competitive environment, indicating that successful talent development requires a nuanced understanding of personal abilities and systemic barriers in the performing arts (Lainson, Braun & Clarke, 2019; Creswell, 1999).

6. FINDINGS AND DISCUSSION

This part discusses the findings of the current study.

6.1. Biographic Data

Table 1.
Demographic Profile of Participants.

Criteria	High School Learner	Frequency
Gender	Male	7
	Females	5
Average Age	18	2
	19	2
	21	5
	25	3
Pseudonyms for interview participants	YXA, YXB, YXC, YXD, YXE, YXF, YXG, YXH, YXI, YXJ, XYK, YXL	12

Table 1 indicates that the sample comprised high school learners of both genders, with 7 males and 5 females, suggesting a near-balanced gender distribution with a slight predominance of males. In terms of age, the participants ranged from 18 to 25 years, with the largest group being 21-year-olds ($n = 5$), followed by 25-year-olds ($n = 3$), and equal numbers of 18- and 19-year-olds ($n = 2$ each). This indicates that most learners were young adults beyond the typical school-leaving age. The table further shows that 12 learners participated in the interview phase and were allocated pseudonyms (YXA–YXL), demonstrating efforts to maintain confidentiality while enabling individual qualitative responses to be reported and compared within the broader demographic profile

6.2. Research Question and Themes

Table 2.
Research Question and Themes.

	Research Question	Research Theme	Sub-theme
1	How do aspiring actors perceive the role of natural talent in their journey towards success in the dramatic arts?	The Dual Nature of Talent and Training	1. Innate vs. Developed Skills Impact of Training on Performance
2	What opportunities do aspiring actors identify as crucial for developing their craft and advancing their careers in the dramatic arts?	Pathways to Professional Development	1. Networking and Industry Connections Educational Opportunities and Skill Development

The table displays the themes created, which are aligned with the research question.

6.3. Perceptions of Natural Talent in Aspiring Actors

To answer research question 1: *“How do aspiring actors perceive the role of natural talent in their journey towards success in the dramatic arts?”*

Participants’ responses to research question 1 suggest that, while natural talent is recognised as a valuable starting point, it is not viewed as the decisive factor in achieving success in the dramatic arts. Participant XYA, for instance, explicitly acknowledged possessing “some innate ability” but was quick to emphasise that “without consistent training, practice, and feedback, that talent does not automatically translate into success on stage or screen.” In this sense, natural talent is constructed as a foundation that must be actively developed through deliberate effort rather than a guarantee of success in and of itself.

“For me, natural talent matters, but it is not the only thing. I believe I do have some innate ability. However, I have learned that without consistent training, practice, and feedback, talent does not automatically translate into success on stage or screen.” (Participant XYA: interview excerpt).

“I strongly believe that training and skill development outweigh natural talent in my journey as an aspiring actor. I have seen how structured classes, rehearsals, and critical reflection have improved my performance far more than simply relying on what I was ‘born with’ (Participant XYB: open-ended question excerpt).

“Networking opportunities are one of the most effective strategies for growth in this industry, in my view. Even if you are talented and well-trained, if you are not meeting casting directors, producers, and other creatives, your chances of being noticed remain very limited” (Participant XYC: interview excerpt).

“Hard work and dedication are more significant to me than talent. I have watched actors with average natural ability excel because they rehearse tirelessly, show up prepared, and keep pushing through rejection. At the same time, some naturally gifted people fall behind because they do not put in the same effort” (Participant XYD: interview excerpt).

Participant XYB highlighted that training and skill development outweigh natural talent in acting, as structured learning can significantly improve performance. Participant XYD added that hard work and dedication often allow average actors to succeed, while some naturally gifted individuals may fall behind without effort.

Participants highlighted that success in the dramatic arts relies not just on talent and training, but also on networking. For example, Participant XYC noted that building connections with industry professionals is crucial, as even talented actors can remain unnoticed without these relationships. Thus, while talent is important, sustained effort and strategic networking are crucial for aspiring actors.

To respond to theme 1: *The Dual Nature of Talent and Training*

Sub-theme 1: *Innate vs. Developed Skills Impact of Training on Performance*

The participants' responses highlight that natural talent is just one aspect of achieving success in the dramatic arts, emphasising its role as a starting point that requires emotional, technical, and relational growth. Participant XYE noted that emotional intelligence and interpersonal skills are “more important than raw talent,” suggesting that the ability to collaborate and respond to a director's vision is essential for believable performances.

Training is transformative for actors. A drama degree enhances credibility (Participant XYF), and online courses offer flexible learning (Participant XYK). Experience and relationships are key, with audition practice (Participant XYH) and community theatre (Participant XYJ) providing vital growth opportunities. Networking (Participant XYG) and mentorship (Participant XYI) are essential for career growth, highlighting the importance of talent recognition and access to social capital in an actor's journey.

“I think emotional intelligence and interpersonal skills are more important than raw talent for lasting success in acting. Being able to read people, manage my emotions, work well with a cast and crew, and respond sensitively to a director's vision helps me create more believable characters” (Participant XYE: interview excerpt).

“Obtaining a degree in drama and performing arts feels essential for my career advancement. A formal qualification not only builds my technical skills but also gives me credibility in the industry and exposes me to theory, history, and professional networks I would not access on my own” (Participant YXF: open-ended question excerpt).

“I consider networking events, such as industry meet-and-greets, crucial for my career development. These events allow me to introduce myself, learn about upcoming projects, and make personal impressions that a showreel alone cannot create” (Participant XYG: interview excerpt).

“Gaining audition experience is critical for improving my chances of landing roles. The more I audition, the better I understand how to interpret briefs quickly, manage anxiety in the room, and adjust my performance when given direction on the spot” (Participant XYH: interview excerpt).

“I view mentorship from established professionals as an essential opportunity for growth. Having someone who has already navigated the industry to guide me, critique my work, and offer practical advice helps me avoid common mistakes and stay motivated” (Participant XYI: interview excerpt)

“Involvement in community theatre productions is vital in honing my craft. These productions give me regular performance opportunities, help me experiment with different characters, and teach me the discipline of working within an ensemble and a rehearsal schedule” (Participant XYJ: open-ended question excerpt).

“Online courses and resources have been invaluable for developing my acting skills and my knowledge about the industry. They allow me to learn at my own pace, revisit complex material, and access insights from international practitioners that I would not otherwise meet.” (Participant XYK: open-ended question excerpt).

“I see success in acting as a combination of training, hard work, networking, and emotional intelligence, rather than natural talent alone. This might be different for each person, but in my case, I feel that building experience and professional connections is what will move my career forward” (Participant XYL: interview excerpt).

Participants like XYL emphasised that success is a "combination" of natural talent and factors such as training, hard work, networking, emotional intelligence, and experience. XYL emphasised the importance of professional connections, suggesting that while talent is valuable, it must be complemented by skill development and reflective practice to be truly effective.

7. DISCUSSIONS

The findings emphasise the foundational role of natural talent in the dramatic arts, while understanding the necessity of training for success. Participants viewed innate abilities as a crucial prioritised skill development, aligning with Connell et al. (2020), who argue that talent alone is insufficient without rigorous practice. This dual nature mirrors the genetic-environmental interplay (Kearney & Levine, 2020), where genetic predispositions, such as emotional expressivity, require coaching to manifest professionally. In South African contexts, resource constraints exacerbate this issue, as raw talent from marginalised communities requires structured outlets to compete, supporting Sparling (2021) in highlighting the importance of environmental supports. Networking and educational opportunities emerged as key pathways, where the need for valuing workshops, mentorship, and community theatre was indicated. These findings align with Hatami's (2023) findings on the benefits of formal training in building versatility across genres, as supported by Kearney and Levine's (2020) findings on the effectiveness of workshops in overcoming stage fright through repeated exercises. Empirical studies, such as Lawal et al. (2023), highlight the role of local theatre in skill-building for underrepresented actors. Participants consistently downplayed natural talent as a standalone predictor of achievement, instead emphasising the importance of training, hard work, networking, emotional intelligence, formal education, mentorship, audition experience, community involvement, and online resources. The themes

align with the principles of reflexive thematic analysis (Mkwananzi & Melis Cin, 2020), where open-ended responses and interview excerpts reveal nuanced, participant-driven insights into career trajectories in a competitive field (Monaco, 2024; O'Dell, 2025; Oliver, 2025).

7.1. Talent vs. Deliberate Development

Participants overwhelmingly positioned natural talent as a mere "starting point" rather than a determinant of success. For example, Participant XYA acknowledged innate ability but stressed that "without consistent training, practice, and feedback, talent does not automatically translate into success." At the same time, XYB asserted that "training and skill development outweigh natural talent." Similarly, XYD observed talented actors faltering without "hard work and dedication," and XYL integrated this view holistically: "success in acting [is] a combination of training, hard work, networking, and emotional intelligence." The perspective aligns with talent development literature, which suggests that innate gifts require cultivation through structured practice (Schnyder et al., 2021). In the performing arts context, it counters romanticised notions of genius, aligning with grounded theory explorations of actors' psychological well-being, which prioritise resilience and effort over raw ability (Şuruba-Rusen et al., 2020). These findings challenge excellence gap models in creative education (Yende, 2025), suggesting that aspiring actors in resource-constrained settings value agency through practice, much like migrant youth who leverage collective agency for their aspirations (Mkwananzi & Melis Cin, 2020).

7.2. Interpersonal and Emotional Competencies

Emotional intelligence and interpersonal skills emerged as pivotal for "lasting success", with Participant XYE emphasising abilities to "read people, manage my emotions, work well with a cast and crew, and respond sensitively to a director's vision." This theme emphasises the relational demands of acting, where empathy facilitates the creation of believable characters and promotes effective ensemble dynamics (McAvoy & O'Connor, 2022). Such views align with broader research in the performing arts on psychological well-being (Mkwananzi & Melis Cin, 2020) and emotional resilience (Oliver, 2025). In diverse industry contexts, these skills mitigate barriers like rejection and burnout (Schnyder et al., 2021; Şuruba-Rusen et al., 2020), paralleling participatory theatre frameworks for diversity management (Mergen & Güven, 2025). Participants' emphasis here reflects a mature understanding of acting as socially embedded, beyond technical prowess (Yende, 2025).

7.3. Networking, Mentorship, and Experiential Strategies

Networking is a key strategy in the arts, with Participant XYZ emphasising its value in connecting with industry professionals. At the same time, Participant XYG finds "industry meet-and-greets" beneficial for personal connections. Additional growth factors include mentorship (Participant XYI), audition experiences (Participant XYH), community theatre, formal degrees (Participant YXF), and online courses (Participant XYK), all of which provide crucial growth opportunities. These strategies align with perspectives in performing arts management (Mkwananzi & Melis Cin, 2020) and alum networks (Fisher & Price, 2021). Mentorship models, such as the virtual CASE framework (Kahl, 2019; Kearney & Levine, 2020), and community interventions support mid-career sustainability and address exclusionary barriers in inclusive education (Collins et al., 2022), aligning with the dramatic arts' role in special education.

7.4. Implications for Dramatic Arts Education

Collectively, the study findings advocate for a holistic training paradigm that integrates technical, emotional, and networked development, as summarised by Participant XYM: "Continuous learning, audition experience, mentorship, and strategic networking truly shape an actor's journey." This supports reflexive thematic analysis in qualitative arts research (Mkwananzi & Melis Cin, 2020), urging drama curricula to prioritise experiential learning over talent myths.

8. RECOMMENDATIONS

The study recommendations are based explicitly on the profound gaps in talent nurturing within South Africa's dramatic arts sector, particularly in the Eastern Cape, where socioeconomic barriers have hindered the development of innate abilities among young people. Recommendations thus emerge not merely as prescriptive actions but as interconnected strategies to foster sustainable ecosystems for artistic growth. Educational institutions and theatre academies could prioritise talent scouting programs in rural schools, integrating improvisational workshops and mentorship schemes that recognise innate expressiveness over formal credentials. Such initiatives, informed by the study's findings, could enable actors to partner with local festivals to create pipelines from community stages to professional auditions in schools and local communities, thereby democratising access. Policymakers may bridge the implementation gaps between SDG 4 and SDG 8 by allocating dedicated funding for dramatic arts hubs in underserved regions and incentivising collaborations between government, NGOs, and industry stakeholders. These hubs would offer subsidised training, digital platforms for virtual auditions, and entrepreneurship modules to transform raw talent into viable careers, reducing youth unemployment.

Community leaders and artists hold pivotal roles in sustaining momentum through volunteer-led talent identification drives and alum networks, ensuring cultural relevance and inclusivity. Ultimately, these discursive pathways require a collective commitment to nurture natural talent, unlocking the dramatic arts as a catalyst for social cohesion and economic vitality in post-apartheid South Africa.

9. CONCLUSION

The current study illuminated aspiring actors' perceptions of natural talent as a foundational yet insufficient element for success in dramatic arts, emphasising the primacy of structured training, hard work, networking, and emotional intelligence. Participants, purposively sampled from high school learners aged 18-25 in the Eastern Cape, revealed through thematic analysis of structured interviews that innate abilities, such as expressiveness, required refinement through formal education, community theatre, mentorship, and audition experience to navigate competitive landscapes marked by resource scarcity and urban-rural divides. Grounded in Howard Gardner's Theory of Multiple Intelligences, findings aligned with literature highlighting interpersonal and bodily-kinesthetic intelligences as cultivable through environmental supports, countering essentialist views of talent.

The study highlights the need for professional development pathways for underrepresented youth in South Africa through the integration of performing arts in communities. It calls for reforms to include drama curricula in rural high schools and partnerships with local theatres to create equitable opportunities. Policymakers should fund training hubs that combine in-person and digital resources, allowing community members to

offer mentorship and help build resilience in young artists. These efforts aim to empower youth, preserve culture, and elevate the dramatic arts as a societal asset, with future research suggesting the examination of long-term impacts.

10. FUTURE RESEARCH DIRECTIONS

Future research on natural talent in the dramatic arts should extend beyond Eastern Cape high school learners to include longitudinal tracking of career trajectories and the impact of training and networking on long-term success in a volatile industry. Comparative analyses across South African provinces could highlight regional disparities, contrasting rural initiatives with urban academies to develop scalable models that utilise digital platforms for auditions and virtual mentorship. Quantitative methods, such as surveys and talent aptitude metrics related to Gardner's multiple intelligences, would complement qualitative insights, exploring themes like the role of emotional intelligence and dropout predictors, including socioeconomic barriers. Interdisciplinary studies could examine the interplay between psychology and dramatic arts, assessing their contributions to SDG 8 in creative industries. Collaborative projects with industry stakeholders might test subsidised hubs for portfolio development and gig economy engagement. Additionally, international comparisons, such as with Nigeria's Nollywood, could reveal strategies for decolonising talent pipelines and amplifying underrepresented voices. Ultimately, participatory action research is essential for empowering aspiring actors as co-investigators in advancing equitable performing arts education.

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Short biographical sketch: Limkani Sincuba is a distinguished Post-Doctoral Fellow in the Department of Education at Walter Sisulu University, South Africa, where she has made significant contributions to educational research and teaching over the past decade. Holding a PhD in Education, her work focuses on enhancing trilingual pedagogy in dramatic arts education, with a strong commitment to educational equity and inclusivity in both urban and rural contexts. Limkani Sincuba's research investigates innovative approaches to language acquisition, critical skills development, and transformative learning, particularly through the integration of African cultural narratives and modern technology. Beyond her academic achievements, she is dedicated to community service, volunteering at local centres and supporting her family, including her husband and several adopted children. Her passion for historical literature and her advocacy for sustainable education have a multifaceted impact in South African academia.

Chapter # 4

FROM SIMULATED CLASSROOMS TO REAL-WORLD READINESS: RETHINKING MICRO-TEACHING FOR ECONOMICS PRE-SERVICE TEACHER PREPARATION

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ABSTRACT

Micro-teaching provides pre-service teachers with a valuable platform to develop and refine their pedagogical skills. This chapter examines the perceptions of third-year Economics pre-service teachers at a South African university regarding the effectiveness of micro-teaching. Using semi-structured interviews within a qualitative case study design and interpretivist paradigm, and drawing on a small purposive sample of three participants, the study offers an in-depth, exploratory account of their experiences rather than generalisable findings. Three key themes emerged: confidence building, enhanced subject knowledge, and the value of feedback. The analysis is framed by Bandura's Social Cognitive Theory, highlighting the importance of self-efficacy and observational learning. Although participants recognised the benefits of micro-teaching in bridging theoretical knowledge with classroom practice and in enhancing their perceived readiness for real classrooms, they also reported challenges such as limited resources, time constraints, and rigid lesson structures. The study relies primarily on self-reported experiences, and the absence of observational or documentary data is acknowledged as a limitation. Nevertheless, the chapter offers recommendations for enhancing micro-teaching within teacher education and outlines directions for future research, with implications for policy and practice across the sector. Given the small purposive sample (three participants) and reliance on interview data, the findings are exploratory and not statistically generalisable, but they offer context-specific insights and directions for future research.

Keywords: micro-teaching, pre-service teachers, economics education, teacher preparation, pedagogical skills development.

1. INTRODUCTION

Economics equips learners with critical decision-making and problem-solving skills for navigating resource-scarce environments while fostering a deeper understanding of economic systems and human behaviour (Jana, 2018; Olagunju, 2019). Effective Economics education, however, is contingent upon well-prepared educators. Yet many teachers face challenges such as inadequate pedagogical content knowledge, ineffective lesson planning, and insufficient training, particularly in South Africa (Manzi & Moreeng, 2023). Micro-teaching is an essential tool in pre-service teacher education, offering a structured environment for aspiring educators to practice and refine teaching strategies through constructive feedback (Msimanga, 2021). Despite its significance, limited research has explored pre-service Economics teachers' perceptions of micro-teaching, necessitating further investigation into its effectiveness in bridging theoretical knowledge and practical application.

This study addresses this gap by examining the experiences of third-year pre-service Economics teachers at a South African university, employing Bandura's Social Cognitive Theory to analyse how self-efficacy and observational learning influence teacher development. Key challenges such as resource limitations and time constraints are explored, highlighting areas for improvement in teacher training programs (Thaba-Nkadimene & Mmakola, 2020). Given its small, purposive sample and focus on a single institutional context, this chapter is positioned as an exploratory case study rather than a comprehensive evaluation of micro-teaching in Economics education. The findings provide contextually rich insights into how a small group of pre-service teachers understand and experience micro-teaching, but they are not intended to be statistically generalisable. Instead, they aim to stimulate further empirical work and methodological innovation in this area.

The study responded to the following research questions:

1. What are the perceptions of pre-service Economics teachers regarding the role of micro-lessons in their teacher education?
2. What challenges do pre-service Economics teachers experience during micro-lessons?

2. BACKGROUND

2.1. Economics Education in South Africa

Economics, the study of how individuals, businesses, governments, and societies allocate scarce resources to meet unlimited needs, plays a pivotal role in developing learners' decision-making, problem-solving, and analytical skills (Jana, 2018; Ajani, 2023). In South Africa, the Curriculum Assessment Policy Statement (CAPS) embeds Economics in the Further Education and Training (FET) phase, structured into microeconomics, macroeconomics, economic pursuits, and contemporary economic issues to foster a comprehensive understanding, rational decision-making, and active citizenship (Adu, 2023). Beyond academic content, Economics education aims to cultivate positive economic attitudes and equip learners for participation in complex socio-economic environments (Olagunju, 2019).

However, persistent challenges, including insufficient pedagogical content knowledge, inadequate qualifications, and limited resources, undermine teaching effectiveness and learner outcomes (Thaba-Nkadimene & Mmakola, 2020). Teacher-centered approaches, poor lesson preparation, and weak integration of teaching aids further exacerbate these issues, particularly in under-resourced schools (Adebola & Tsotetsi, 2022). Systemic constraints such as resource shortages, language barriers, and high-stakes examinations perpetuate a "teach to the test" culture that diminishes problem-solving skills (Maistry, 2010; Adu, 2023). Vague curriculum guidelines, learner disengagement, especially in mathematical and statistical areas, and limited professional development for teachers, including those in TVET colleges, deepen the skills gap (Nkwadipo & Rabaza, 2021). While existing research identifies these barriers, little is known about how pre-service Economics teachers experience and address them during training. This gap underpins this study, which examines their perceptions of micro-teaching as a strategy for overcoming pedagogical and systemic challenges.

2.2. Origins and Evolution of Micro-Teaching in Teacher Preparation

Micro-teaching, developed in the 1960s by Dwight W. Allen, is a structured teacher training method that enables pre-service teachers to practice and refine pedagogical skills in a controlled, low-stakes environment (Bush & Allen, 1960; Lozgka, 2024; Reddy, 2019).

It involves delivering short, structured lessons to a small audience, followed by targeted feedback and reflection (Reddy, 2019; Bada & Akinbobola, 2022), fostering competencies in lesson planning, communication, and classroom management, skills particularly valuable in subjects like Economics, where abstract concepts must be made accessible (Azizah & Rahmi, 2019; Bakir, 2014).

Globally, micro-teaching has been adapted to fit diverse educational contexts. While the original Stanford model included cycles of teaching, feedback, and reteaching, variations in lesson length, audience composition, and feedback structures now exist to suit institutional constraints and subject needs (Klinzing & Floden, 1991; Lozgka, 2024). In science education, the focus may be on demonstrating experiments; in language education, on fostering interactive, communicative lessons; and in professional fields such as medicine or law enforcement, on simulating critical workplace interactions (O’Flaherty et al., 2023; Ralph, 2014). This cross-disciplinary adoption underlines the method’s versatility as a practice-based learning tool that bridges theory and practice.

Within initial teacher education, micro-teaching’s iterative cycle of planning, teaching, observing, and reflecting supports the integration of pedagogical content knowledge with practical strategies (Laghari et al., 2021; Kroeger et al., 2024). For Economics pre-service teachers, it enables rehearsal of complex explanations, adaptation to diverse learner needs, and the application of inclusive approaches (Mufidah, 2019; Manzi & Moreeng, 2023). However, common challenges remain: limited opportunities for practice (Hama & Osam, 2021), the artificiality of peer-based simulations (Reddy, 2019; Bada & Akinbobola, 2022), language barriers, and performance anxiety (Makafane, 2020). Such constraints can restrict creativity and reduce the transferability of skills to real classrooms (Manzi & Moreeng, 2023). While its value is well established, there is limited discipline-specific research into micro-teaching in Economics education (Mukuka & Alex, 2024), highlighting the need for contextual adaptations and targeted investigation to maximise its effectiveness.

2.3. Theoretical Framework

Social Cognitive Theory (SCT), developed by Bandura in 1986, highlights the reciprocal relationship between behaviour, cognition, and environment in shaping human learning and development (Koutroubas & Galanakis, 2022). Central to SCT is observational learning, which explains how individuals acquire and maintain attitudes and behaviours through interactions with their environment and feedback mechanisms (Nwosu et al., 2022). A key component of SCT, self-efficacy, is particularly relevant to this study as it explores pre-service Economics teachers’ confidence in their teaching abilities, which is shaped by mastery experiences, mediated learning, and feedback during micro-teaching sessions (Jenkins et al., 2018). Bandura’s self-efficacy concept asserts that individuals’ belief in their capabilities influences their motivation, persistence, and performance (Wilkerson et al., 2023), making it a crucial factor in understanding how pre-service teachers develop pedagogical skills. This framework provides insights into their classroom management strategies, teaching behaviours, and professional development, offering a lens through which the cognitive and environmental influences on pre-service teachers’ engagement with micro-teaching can be examined (Luszczynska & Schwarzer, 2020).

3. METHODOLOGY

This study used a qualitative research approach to examine pre-service Economics teachers’ perceptions and attitudes toward micro-teaching. A qualitative approach was selected for its suitability in exploring human experiences and capturing participants’

subjective interpretations within their natural contexts (Kumatongo & Muzata, 2021). It enabled in-depth insight into how participants made sense of their experiences, revealing factors influencing their views and challenges encountered.

3.1. Research Paradigm

The study was grounded in an interpretivist paradigm, which prioritises understanding participants' lived realities and the meanings they assign to them (Pham, 2018; Alharahsheh & Pius, 2020). This paradigm enabled an exploration of pre-service teachers' unique interpretations and motivations during micro-teaching sessions (Rashid et al., 2019). By recognising multiple realities and the influence of social and cultural contexts, the approach aligned with the study's aim to uncover nuanced factors shaping perceptions and challenges (Kumatongo & Muzata, 2021).

3.2. Research Design

A case study design was used to provide an in-depth, contextualised examination of a specific group of pre-service Economics teachers. This design facilitated detailed insights into the complex interplay between attitudes, behaviours, and micro-teaching practices (Kumatongo & Muzata, 2021), closely reflecting participants' lived experiences (Taherdoost, 2022). While case studies face limitations such as limited generalisability and potential bias (Schoch, 2020), they remain valuable for generating rich, context-specific understanding.

3.3. Participants

Purposive sampling identified three Bachelor of Education pre-service Economics teachers from a cohort of nine enrolled in a full-time methodology module (Moser & Korstjens, 2018; Campbell et al., 2020). Selection was based on direct involvement in micro-teaching and alignment with the study's objectives. These participants, with relevant academic backgrounds and hands-on teaching practice, provided focused and informed perspectives. The small sample size reflects the in-depth, exploratory nature of the case study; as such, the findings are not intended to be generalisable to all pre-service Economics teachers but rather to offer nuanced insights that may be transferable to similar contexts.

3.4. Data Collection

Data were gathered through semi-structured interviews, beginning with open-ended questions to encourage free expression, followed by prompts for deeper exploration (Moser & Korstjens, 2018; Kakilla, 2021). This format allowed alignment with research aims while adapting to participants' responses. Interviews were recorded and supported by field notes to ensure accuracy, creating a reliable foundation for analysis. Data sources were therefore limited to participants' self-reported experiences captured in interviews and researcher field notes; no classroom observations or documentary artefacts (such as lesson plans or assessment records) were collected, which constrains the depth of data triangulation and is acknowledged as a limitation of the study's design.

3.5. Data Analysis

Thematic analysis was applied to identify and interpret patterns in the data (Castleberry & Nolen, 2018). Following Braun and Clarke's six-step framework, familiarisation, coding, theme development, theme review, definition, and reporting (Braun & Clarke, 2006; Dawadi, 2020), the process yielded themes including confidence-building, classroom management challenges, and theory-to-practice integration. This method's flexibility and rigour ensured findings were firmly grounded in participants' lived experiences (Islam & Aldaihani, 2022).

3.6. Ethical Considerations

Ethical clearance was obtained from the University of Johannesburg. Participants received information letters outlining the study's purpose, objectives, and procedures, and signed consent forms prior to participation. They were informed of their right to withdraw at any time without penalty. Measures to safeguard anonymity, confidentiality, and data security were observed, and participants could decline to answer any questions they found uncomfortable.

4. RESULTS

4.1. Perceptions of Pre-Service Economics Teachers regarding Micro-Lessons

The study found that pre-service Economics teachers generally perceived micro-teaching as a useful preparatory tool that allows them to practice and refine their teaching strategies in a controlled environment. Participants described micro-teaching as a platform that helped them build confidence, structure their lessons effectively, and gain familiarity with classroom management techniques.

4.1.1. Confidence-Building and Skill Development

Participants reported that micro-teaching was vital in increasing their confidence in lesson delivery. The simulated teaching experience allowed them to refine their teaching approaches and practice classroom engagement strategies in a controlled environment before real classroom exposure. Pre-service teachers described micro-teaching as:

It is very nice. It is like knowing something to a certain extent and then being able to practice it (PST1).

It allows me to test my teaching strategies and see how students react (PST2).

I feel more prepared to handle a real classroom after micro-teaching sessions (PST3).

Participants also emphasised their role in refining their teaching:

I think micro-teaching is a form of preparation. It allows us to see what it would be like to teach in real life, even though it is not the same (PST1).

Micro-teaching prepares us for conducting lessons and structuring our teaching. Moreover, it teaches us how to organise a lesson from introduction to conclusion (PST2).

This finding aligns with prior studies that emphasise the role of micro-teaching in improving self-efficacy (Jenkins et al., 2018).

4.1.2. Bridging Theory and Practice

Participants noted that micro-teaching served as an essential link between theoretical knowledge gained in coursework and its practical implementation in the classroom. The sessions helped them transition from understanding content to effectively communicating it to learners. It served as an eye-opener, revealing the complexities of lesson planning and classroom engagement. Pre-service teachers stated:

It prepares you for the school environment. It also helps you adjust in terms of how to present lessons (PST1).

I learned how to translate what I read in textbooks into actual lessons (PST2).

The experience helped me understand the importance of lesson structure and engagement (PST3).

These findings reinforce research by Kroeger et al. (2024), highlighting micro-lessons as an essential tool for pedagogical refinement in teacher training.

4.1.3. Content Mastery and Feedback-Driven Improvement

Pre-service teachers expressed that micro-teaching facilitated the improvement of their Economics subject-specific content knowledge and pedagogical skills. They also valued feedback from peers and supervisors, which helped them refine their teaching and lesson-delivery techniques. Pre-service teachers commented:

I think it is an improvement on my content knowledge and how to deliver the subject better. Furthermore, the feedback we get from peers and lecturers is beneficial in improving my teaching (PST1).

Constructive feedback gave me insights into areas I need to work on (PST2).

Understanding how to convey complex economic concepts became easier. It also helps us refine how we deliver subject content effectively (PST3).

These perceptions align with existing literature highlighting the micro-lesson role in fostering pedagogical competence and self-efficacy, further reinforced by studies emphasising the benefits of feedback in teacher development (Bandura, 1986; Bakir, 2014; Kroeger et al., 2024).

However, some participants also felt that while micro-teaching was beneficial, it was not always sufficient in preparing them for real-life classroom challenges, as it did not fully replicate the challenges faced in actual classrooms. Pre-service teachers mentioned:

Micro-teaching helps, but it does not fully prepare us for dealing with real learners in a real classroom setting (PST2).

It was not that bad, but it was not enough and should be more structured (PST3).

4.2. Challenges Pre-Service Economics Teachers Face during Micro-Lessons

Despite its perceived benefits, participants identified several challenges in micro-teaching that affected their ability to maximise the experience. The following sub-themes emerged:

4.2.1. Time Constraints

A common concern among the pre-service teachers was the limited time allocated for micro-lessons. They felt the sessions were too short to cover lesson content comprehensively and practice and refine their teaching skills effectively. The pre-service teachers noted that:

I feel like the time given is too short, actually, to deliver a proper lesson. (PST1).

I had to rush through my lesson and could not focus on student questions (PST2).

More time would allow for better practice and feedback application (PST3).

This is consistent with research indicating that limited time in micro-teaching restricts experiential learning (Hama & Osam, 2021).

4.2.2. Classroom Management and Student Engagement Issues

The pre-service teachers found maintaining discipline and keeping students engaged during lessons challenging. They shared:

In class, class management and sometimes keeping the students engaged were complex (PST1).

Students sometimes lose focus, and I struggle to bring them back (PST2).
Handling different learning paces in the same classroom is challenging (PST3).

These findings align with Reddy (2019), who identified classroom management as a critical hurdle for novice teachers.

4.2.3. Language Barriers and Student Diversity

Language barriers emerged as a significant challenge, particularly in schools where English is the medium of instruction, yet students are more comfortable in their native languages. Some pre-service Economics teachers mentioned difficulty teaching Economics concepts due to language differences. They stated:

The policy only permits us to teach in English, but most students understand better in their mother tongue (PST1).
Explaining economic concepts in a way that students from different backgrounds can understand is difficult (PST2).
Some students struggle with English terminology, making engagement harder (PST3).

This challenge is well-documented in South African educational research, emphasising the need for multilingual instructional strategies (Makafane, 2020).

4.2.4. Formalities and Rigidity in Lesson Planning

The pre-service teachers found the structured nature of micro-teaching sessions restrictive. They felt that the lesson planning process lacked flexibility and did not allow them to experiment with different teaching strategies. One pre-service teacher noted:

I would not say I like the formalities. It would be better if we had more flexibility in lesson delivery (PST1).

5. DISCUSSION

The study's findings suggest that, for the participants in this exploratory case, micro-teaching functioned as an important bridge between theory and practice. Participants reported significant growth in their confidence and perceived teaching skill after micro-lesson sessions, which aligns with Bandura's concept of mastery experiences bolstering self-efficacy (Bandura et al., 1986). This reported boost in confidence echoes prior research showing that micro-teaching can improve novice teachers' sense of competence and self-belief (Bakır, 2014; Msimanga, 2021). In our context, structured practice teaching allowed participants to refine lesson planning, communication, and classroom management strategies in a low-stakes environment, consistent with the established value of micro-teaching in teacher education (Reddy, 2019; Bada & Akinbobola, 2022). Notably, the opportunity to translate Economics content knowledge into teachable lessons helped solidify subject mastery while honing pedagogical techniques. However, it is important to emphasise that these conclusions relate to participants' self-reported experiences rather than externally observed teaching performance.

Crucially, the simulated classroom experience provided immediate feedback and reflection, which participants credited for their improvement. Feedback from peers and mentors enabled iterative refinement of teaching approaches, illustrating how observational learning and social feedback drive skill development (Bandura et al., 1986; Bakır, 2014). Such feedback-driven growth aligns with social cognitive theory, where seeing one's teaching through others' eyes and adjusting accordingly builds both competence and

confidence (Jenkins et al., 2018; Luszczynska & Schwarzer, 2020). It is therefore unsurprising that participants perceived themselves as better prepared to handle real classrooms after engaging in micro-teaching, even though the study did not follow them into actual school placements to observe whether and how these perceived gains translated into practice.

Despite these benefits, the discussion must acknowledge the limitations of the micro-teaching format revealed by the study. Consistent with broader literature, participants noted that short teaching slots and an artificial peer audience constrained the authenticity of the experience (Hama & Osam, 2021; Makafane, 2020). Time pressure was a pervasive concern, as rushed lessons limited engagement and classroom management practice, reflecting known issues of micro-teaching's compressed format (Hama & Osam, 2021). Likewise, the rigid lesson plan structure and lack of real learner diversity meant that some classroom challenges, such as managing varied learning needs and language barriers, remained only partially addressed. These challenges resonate with persistent problems in South African Economics classrooms, including resource limitations and language mismatches (Thaba-Nkadimene & Mmakola, 2020; Makafane, 2020). Participants' difficulty in teaching exclusively in English to learners more comfortable in other languages underscores the need for multilingual strategies, a well-documented hurdle in the local context (Makafane, 2020).

Overall, our findings affirm that micro-teaching is an invaluable component of teacher preparation, fostering pedagogical skills and confidence in alignment with social cognitive principles and existing studies. At the same time, they highlight that to prepare pre-service teachers for real-world readiness, micro-teaching programs must truly evolve. Addressing structural constraints by extending practice time, incorporating more realistic student interactions, and providing resources for creative teaching would enhance the transfer of micro-lesson gains to actual classroom performance. Such improvements are crucial for maximising micro-teaching's effectiveness, as indicated by both our participants and the wider literature calling for updated approaches to this classic training technique (Hama & Osam, 2021; Mukuka & Alex, 2024). By situating our Economics-focused results within the larger discourse on teacher education, this discussion underscores that while micro-teaching builds a strong foundation (Bakır, 2014; Bada & Akinbobola, 2022), it is most effective when integrated with responsive, context-aware training that addresses the fundamental challenges new teachers will face.

Several methodological limitations must be acknowledged when interpreting these findings. First, the case study draws on a very small purposive sample of three pre-service Economics teachers from a single South African university, which severely limits the generalisability of the results. Second, data were generated solely through semi-structured interviews and field notes, without the inclusion of classroom observations, video recordings, or lesson-planning documents. This lack of data triangulation means that conclusions about the effects of micro-teaching rest primarily on participants' self-reported experiences and cannot be taken as direct evidence of classroom behaviour or learner outcomes. Third, the study did not track participants into their subsequent teaching practice, so claims regarding "real-world readiness" refer only to perceived preparedness, not demonstrated competence in school settings. Future research could address these gaps by employing larger and more diverse samples across institutions, incorporating multiple data sources (including observations and document analysis), and longitudinally linking micro-teaching experiences to performance in practicum and early-career teaching.

6. CONCLUSION AND RECOMMENDATIONS

Within the limits of this small, exploratory case study, the findings highlight the important role that micro-teaching can play in preparing pre-service Economics teachers by fostering confidence, improving content mastery, and enhancing pedagogical strategies. Participants recognised micro-teaching as a valuable tool for bridging theoretical knowledge with practical classroom experience. However, significant challenges persist, including limited practice opportunities, resource constraints, time limitations, and difficulties managing student engagement. These barriers hinder micro-teaching effectiveness and raise concerns about pre-service teachers' perceived readiness for real-world classroom environments. Furthermore, language barriers and rigid lesson planning structures emerged as additional obstacles, limiting the adaptability and responsiveness of pre-service teachers in diverse classroom settings. These findings reinforce the urgent need for reforms in teacher training programs to optimise the benefits of micro-teaching and address the structural limitations identified in this study.

At the policy level, the findings point to the need for deliberate alignment between teacher education curricula and practical training requirements. Micro-teaching should be embedded earlier and more frequently within university programs, with time allocations that allow for iterative practice and reflection. National and provincial departments could strengthen this through teacher preparation standards that recognise micro-teaching as essential for competency development. Language-in-education policies should encourage multilingual pedagogical strategies, and resource provision, particularly teaching aids, simulation tools, and mentorship support, should be prioritised in funding to ensure equitable access across institutions.

Several recommendations are proposed to enhance the effectiveness of micro-teaching in Economics teacher education. Firstly, universities should integrate micro-teaching sessions earlier in the curriculum and extend their duration to allow pre-service teachers more opportunities for practice and reflection. Secondly, structured mentorship programs should be established, pairing pre-service teachers with experienced educators who provide constructive feedback and professional guidance. Additionally, institutions should invest in technological tools and digital simulations to mitigate resource constraints and create more dynamic micro-teaching environments. Adopting multilingual instructional strategies is crucial for improving content delivery and fostering inclusive learning experiences. Finally, curriculum designers should revise micro-teaching frameworks to incorporate flexible lesson planning and encourage pre-service teachers to experiment with diverse pedagogical approaches.

Taken together, these recommendations and limitations indicate that the chapter's primary contribution lies in opening an exploratory, Economics-specific conversation on micro-teaching in South Africa, which future larger-scale and multi-method studies can substantially extend.

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Chapter # 5

LEARNING ANALYTICS TO SUPPORT LOW-ACHIEVING STUDENTS IN PROGRAMMING EDUCATION

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ABSTRACT

In recent years, providing effective programming education has become an important issue in Japan. This study aimed to support students predicted to have low proficiency by analysing their coding processes. Programming lessons were conducted at a senior high school, and learning analytics were performed using both the frequency of tokens contained in the students' programs and their proficiency levels measured through assessments. Using machine learning with token frequencies as features, a classification model was constructed to identify the lower-achieving group effectively. Furthermore, by examining tokens with low coverage rates in this group and visualising their positions in the exemplar program, patterns were identified that may help pinpoint areas of difficulty. These findings suggest that the proposed analysis method can help support students at risk of low proficiency.

Keywords: programming education, learning analytics, coding process, tokens, machine learning.

1. INTRODUCTION

1.1. Background

Japanese school education is guided by national curriculum guidelines, known as the Course of Study, which are revised approximately every ten years. In the latest revision issued in 2018, programming education was strengthened, and Informatics I, which includes programming as one of its main contents, became a compulsory subject in senior high schools (Ministry of Education, Culture, Sports, Science, and Technology [MEXT], 2018). Consequently, all high school students are required to learn programming.

In Japan, many students take the Common Test for University Admissions. Informatics I was incorporated into this test, with the first administration held in January 2025. The total number of test-takers was 462,066, of which 279,718 took Informatics I (National Center for University Entrance Examinations, 2025). According to statistics from MEXT (2023), the number of third-year senior high school students as of May 2024 was approximately 930,000. Thus, approximately 30% of the cohort had taken the subject, highlighting the growing importance of programming education in senior high schools.

Hasegawa, one of the authors, has been engaged in teaching elective courses, including programming, at the senior high school level for over a decade. Drawing on this experience, it has been consistently observed that, relative to other domains within informatics, students encounter greater difficulty in attaining proficiency in programming. Furthermore, recent revisions to the national Courses of Study, coupled with modifications to university entrance examinations, have not only increased the complexity of programming content but also expanded the cohort of students required to acquire programming skills. Consequently, the

provision of effective programming instruction has emerged as a critical and pressing issue in the context of high school informatics education.

Learning analytics research focusing on programming education has been actively conducted overseas (Ihantola et al., 2015; Humble & Mozelius, 2019). In Japan, there is growing interest in the implementation of learning analytics and the application of its insights in programming education.

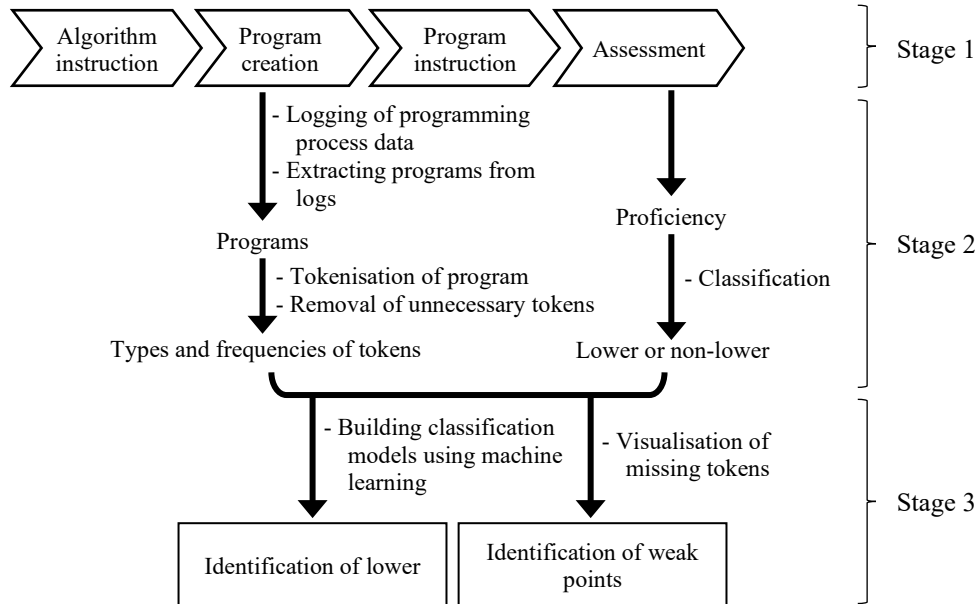
1.2. Research Purpose

Learning support is particularly important for students with lower proficiency levels. However, previous research has suggested that students with lower proficiency often struggle to explain what they do not understand and may be unable to ask teachers questions effectively (Hasegawa & Ito, 2024a). Therefore, this study has two primary aims: to identify students at risk of low proficiency, and to pinpoint the parts of code that they do not fully understand.

1.3. Overview

This study consists of three major stages (Figure 1). The first stage involves a series of teaching practices, including program creation and assessments. The second stage involves data collection and pre-processing during the teaching practice sessions. The third stage involves learning analytics to identify low achievers and the parts of code where their understanding is weak.

Figure 1.
Outline of the research process.



2. TEACHING PRACTICE

2.1. Lessons

In September 2024, Informatics I programming lessons were conducted for 135 second-year students across four classes at a private senior high school. The lessons were conducted by one of the authors, Hasegawa.

The curriculum guidelines for Informatics I specify the following learning objective for programming: “to understand and acquire skills concerning means of expressing algorithms, and methods of utilizing computers and information communication networks through programming”, and “to consider algorithms according to objectives, to express them by appropriate methods, to utilize computers and information communication networks through programming, and to evaluate and improve the process” (MEXT, 2018, p. 191). Furthermore, as concrete examples, the guidelines specify: “to take up activities such as considering and expressing typical algorithms such as searching and sorting, and to deal with methods of expressing algorithms, the importance of correctly expressing algorithms, and differences in efficiency depending on algorithms” (MEXT, 2019, p. 33).

Based on the above, we conducted instructional practice on the unit “Search Programs”. The educational objectives of the unit were to understand algorithms in searching and to develop thinking and expressive skills related to program creation and improvement. Lessons were conducted in accordance with the instructional plans listed in Table 1. JavaScript was used as the programming language. The focus of the analysis in this study was the learning of a binary search program. During the lessons, the teacher explained the algorithm of the target program. Students then created their programs, and the teacher explained the exemplar program. After completing the unit, students’ proficiency was assessed.

Table 1.
Instructional plan of the unit “Search Programs”.

Class*	Instructional content
1	Review of prior learning contents in programming, such as branching, iteration, and arrays.
	Linear search program: - Explanation of algorithm
2	- Program creation (15 minutes) - Explanation of exemplar program - Reflection
	- Confirmation of key points
3	Binary search program: - Explanation of algorithm
	- Program creation (20 minutes) - Explanation of exemplar program - Reflection
5	- Confirmation of key points
	Summary

* The class duration is 45 minutes.

2.2. Assessment

The assessment was conducted using a written test. The assessment consisted of three components.

- (a) Algorithm understanding: one item that did not require programming language expression.
- (b) Program completion: four basic items assessing understanding of the exemplar program.
- (c) Program improvement: one applied item assessing the exemplar program, plus the thinking and expressive skills developed in earlier lessons.

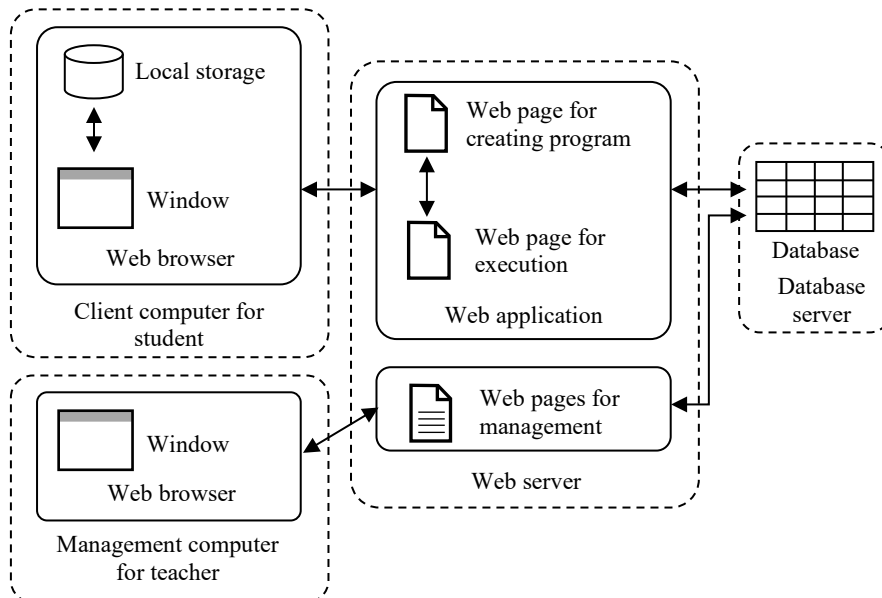
Each item was worth one point. The maximum score is six. The students' scores represent their proficiency in this unit. The purpose of the written test was to serve as a summative assessment of students' proficiency at the end of the unit.

3. DATA COLLECTION AND PRE-PROCESSING

3.1. Programming Data Collection

Students utilized a programming education support system to create their programs. This system was originally developed by Hasegawa and Ito (2024b). The system has functions for program creation and execution, as well as functions for sequentially recording the coding process for individual students. The block diagram of the system is shown in Figure 2. The system is executed using a web browser. When a student enters a key or saves or executes a program, such events are detected by the system. Immediately after detection, the type of event, timestamp, and program at the time of the event are recorded in the database as learning data.

Figure 2.
Block diagram of the programming education support system.

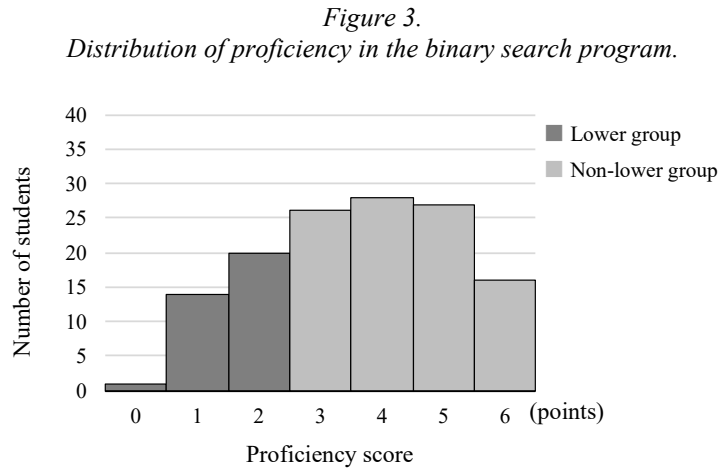


Among the 135 students enrolled in the course, 126 attended the lesson for creating a binary search program. During 20 minutes of program creation, 58,817 learning data records were obtained.

3.2. Distribution of Proficiency and Classification

Previous teaching practices concerning the binary search program showed that it was difficult to find a clear proficiency boundary between the lower and non-lower groups (Hasegawa & Ito, 2025). Therefore, the lowest third of the proficiency distribution was treated as the lower group. According to calculations based on the MEXT statistical data (2024), the average class size in Japanese senior high schools is approximately 35. One-third of this corresponds to slightly over ten students, which can be considered a manageable number for teachers to provide individual support.

A total of 132 students took the assessment. The mean proficiency score of all test-takers was 3.6 points out of 6 ($SD = 1.6$). The proficiency distribution in this study is shown in Figure 3. The cut-off points for the lowest third of the proficiency data was three points. Since there were more students in the non-lower group than in the lower group with a score of 3, it was considered appropriate to include students scoring 3 points in the non-lower group. As a result, 35 students were classified into the lower group, with scores of 0–2 points, and 97 in the non-lower group, with scores of 3–6 points.



3.3. Preliminary Time-Series Analysis of Programming Activity

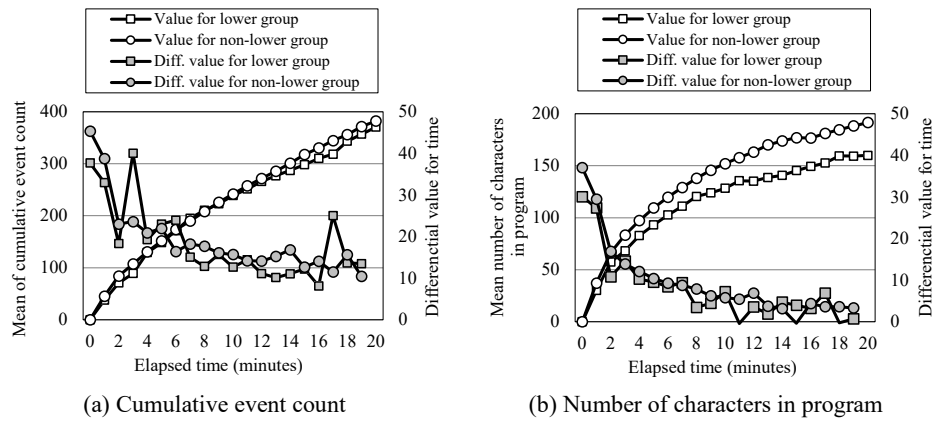
A total of 126 students attended both the program-creation lesson and the assessment. Following a data inspection, the learning data from one student were excluded due to an abnormal amount of text data irrelevant to the programming task. Based on the criteria described in Section 3.2, 30 of the 125 students were classified into the lower group and the remaining 95 into the non-lower group.

For each student, we aggregated the cumulative number of operational events up to each measurement point and the number of characters in the program at each measurement point and then calculated the means of the lower and non-lower groups. The time-series changes in the cumulative number of events and characters in the program for each group are shown in Figure 4.

Both groups exhibited a continuous increase in the cumulative number of operational events. At the 20-minute point, the mean number of operations was 381.9 for the non-lower group and 370.4 for the lower group, with no statistically significant difference observed using a t -test ($p = 0.79$). However, the increase in the number of characters slowed after approximately two minutes. An increase in deletion operations is considered to be the cause. At the 20-minute point, the mean number of characters was 160.0 in the lower group and 191.6 in the non-lower group, and a significant difference was found ($p < 0.01$).

Figure 4.

Time-series mean changes in programming data for the lower and non-lower groups.



3.4. Tokenisation of Programs

Programs that students had created at the 20-minute mark were extracted for learning analytics. First, the programs were divided into tokens. Tokens are the smallest units of a program, and the process of dividing them into tokens is called lexical analysis or tokenisation (Python Software Foundation, 2025). Next, tokens belonging to whitespace, string literals, numeric literals, and tokens that did not appear in the exemplar program were removed, and the number of occurrences of the remaining tokens was aggregated.

4. LEARNING ANALYTICS

First, we attempted to identify students who were likely to belong to the lower-proficiency group based on the number of occurrences of each token during program creation. Second, we attempted to determine the parts of the program in which those students had weak understanding.

4.1. Identification of the Lower Group

In machine learning, predictive models have different names depending on the type of objective variable. Problems in which the objective variable is quantitative are called regression models, and those in which the objective variable is qualitative are called classification models (Hastie, Tibshirani, & Friedman, 2009). We constructed a classification model using machine learning, in which the number of token occurrences was used as a feature, and the categories of the lower and non-lower groups were used as the objective

variables. Representative methods such as logistic regression, decision trees, support vector machines, random forests, and gradient boosting were employed (Géron, 2020).

In this analysis, the dataset available for model construction consisted of only slightly more than 100 records, which was considered too small for machine learning. In general, for the performance evaluation of the models, the dataset is divided into training and validation sets. However, when the dataset is small, the evaluation by one division may be affected by chance, and the results may become unstable. Therefore, in this study, a five-fold cross-validation was adopted for performance evaluation (Géron, 2020).

The precision and recall were used as indicators to evaluate the identification performance of the classification models. Precision indicates the proportion of students who actually belong to the lower group among those predicted to belong to the lower group. Recall indicates the proportion of students predicted to be in the lower group among those who actually belonged to the lower group. There is a trade-off between precision and recall; when one is increased, the other tends to decrease. Since the purpose of this study is to detect the lower group without omissions, it is important to improve recall. Therefore, the hyperparameters in machine learning were adjusted with an emphasis on recall.

The performances of the classification models using the machine learning method are summarised in Table 2. The recall ranged from 0.74 to 0.77, and the precision ranged from 0.70 to 0.78. The method that showed the highest identification performance was gradient boosting, with a recall of 0.77 and a precision of 0.78.

Table 2.
Classification performance by machine learning models.

Model	Recall	Precision
Logistic Regression	0.76	0.71
Decision Tree	0.74	0.70
Support Vector Machine	0.76	0.70
Random Forest	0.74	0.73
Gradient Boosting	0.77	0.78

To evaluate the usefulness of the number of token occurrences as a feature, we constructed classification models using other features and compared their performances. The indicators used as other features were the cumulative number of operational events, the number of characters in the program, and the score on a written test of “Information Society” unit conducted just before the unit “Search Programs”. Gradient boosting was employed as a machine learning method. The classification performance according to feature type is presented in Table 3. The recall of the classification models using other features remained in the range of 0.56–0.61, and precision remained in the range of 0.57–0.62. These results demonstrate that the number of token occurrences is a useful feature for identifying proficiency.

In general, data in which the number of samples between classes is imbalanced is called imbalanced data, and such data makes it difficult to train appropriate models. In this study, as the ratios of the lower and non-lower groups were imbalanced, it was difficult to construct a model with high identification performance. Nevertheless, by applying machine learning with gradient boosting and using the number of tokens as features, we constructed a model that identified the lower group with a certain level of recall and precision.

Table 3.
Classification performance by feature types.

Feature type	Recall	Precision
Token occurrences in created programs	0.77	0.78
Number of operational events during programming	0.57	0.57
Number of characters in the program	0.61	0.62
Score on the written test in the “Information Society”	0.56	0.59

4.2. Identification of Weaknesses in the Lower Group

In the lessons, instructions were provided with the exemplar program in mind before the students created their own programs. Therefore, it was assumed that students attempted to create programs similar to the exemplar program. We defined the coverage rate as the ratio of the number of occurrences of a given token in a student program to the number of occurrences of the same token in an exemplar program. Attention was focused on tokens with a lower coverage rate in the lower group than in the non-lower group. By visualising on the exemplar program the tokens whose coverage rate was low in the lower group programs, we attempted to identify the parts that students in the lower group did not understand.

First, the mean coverage rate of each token was calculated for the lower and non-lower groups, and the tokens with significant differences between the two groups were identified. Significance was determined using a *t*-test at a 0.01 level. Next, the entire exemplar program was displayed, and tokens with significantly lower coverage rates were highlighted. Among the tokens with low coverage rates, `while`, `/`, `Math.floor`, `<=`, and `>` appeared only once in the exemplar program, and therefore their positions could be identified. These tokens were visualised by reversing the background colour to black and font colour to white. Tokens that appeared more than once in the exemplar program were visualised with a grey background (Figure 5).

As a result, it was found that in the lower group, many students were unable to write the part using `while` and its condition in line 5, and the part in line 6, where the result of division by `/` is processed by `Math.floor()`.

Regarding the description in line 5, the binary search program contains a loop structure and is written using `while`. Before learning the binary search program, students had learned loop structures using `for` and `while`. Moreover, memorising how to write syntax was not a learning objective, so when creating the binary search program, explanations of how to write the `while` syntax and how its functions were presented as hints. However, in reality, many students in the lower group were unable to write a program using `while`. From this, it can be considered that more intensive instruction is required to promote understanding of loop structures using `while`.

Regarding the description in line 6, although explanations of the function and how to write `Math.floor()` were presented as hints during program creation, students had no prior experience of creating programs using `Math.floor()`. Furthermore, although the content of line 6 is short and expressed as a single line, it is a complex structure that encompasses multiple processes. Specifically, the following series of processes are summarised in one line: (1) adding the variable `L` representing the lower-bound index of the search range and the variable `R` representing the upper-bound index; (2) dividing the result of addition by 2; (3) extracting only the integer part of the result of division; and (4) assigning the integer part

to variable *i*. Expressing such a structure encompassing multiple processes in a programming language was considered difficult for students in the lower group.

As described above, by visualising the exemplar program and tokens with low coverage rates in the programs of the lower group, we obtained grounds for identifying the parts that students in the lower group did not sufficiently understand.

Figure 5.
Visualisation of tokens with low coverage rates in the lower group.

```

1  let a = [14,17,20,22,24,26,28,30,31,33];
2  let s = prompt();
3  let L = 0;
4  let R = a.length-1;
5  while(L <= R) {
6      let i = Math.floor((L + R) / 2);
7      if(a[i] == s){
8          alert(s + ' is found at index ' + i + '.');
9          break;
10     }
11     if(a[i] > s){
12         R = i - 1;
13     }
14     if(a[i] < s){
15         L = i + 1;
16     }
17 }

```

5. CONCLUSION

This study focused on exploring an approach to support students predicted to have lower proficiency. Programming lessons were conducted at a senior high school and learning analytics were performed based on both the frequency of tokens contained in students' programs and proficiency measured through assessments.

Using machine learning with token frequencies as features, a classification model was constructed to identify the lower-achieving group with reasonable accuracy. Additionally, by examining tokens with low coverage rates in this group and visualising their positions in the exemplar program, insights that may help identify areas of weaker understanding were obtained. These results provide a foundation for designing timely and data-informed support for students whose proficiency is at risk of remaining low, indicating substantial potential for practical implementation in programming education.

Although the present analysis focused on a binary search program, further investigation is needed to determine whether this method can be applied to other programming tasks. Building on these findings, future work will focus on developing concrete approaches to integrate this analytical method into instructional support.

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Chapter # 6

CULTURAL ONTOLOGY IN MATHEMATICS EDUCATION: A pedagogical framework for geometry instruction in pre-service teacher training

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ABSTRACT

This study explores integrating historical perspectives into geometry instruction for pre-service mathematics teachers. Traditional curricula portray mathematics as fixed, emphasizing Euclid, Pythagoras, and Thales, while neglecting non-Euclidean contributors like Lobachevsky, Bolyai, and Riemann. Eight third-year students at Achva Academic College engaged in a learning sequence using the Discipline-Culture structure (Tseitlin & Galili, 2005) to examine shared and discipline-specific contexts, as well as contested concepts. They analyzed historical definitions of angles and expanded the DC-Structure with Non-Euclidean axioms. Guided by Cultural Ontology, students recognized mathematics as evolving perspectives. This study employs a mixed-methods approach through triangulation analysis, integrating qualitative research, ontology construction, and historical analysis. Findings showed varied engagement, fostering reflective, informed educators.

Keywords: discipline culture, cultural ontology, meaningful learning, geometry.

1. INTRODUCTION

In today's rapidly evolving world, groundbreaking innovations and societal transformations are unfolding at an unprecedented pace. To not only adapt to these changes but to actively shape them, the younger generation must cultivate a new repertoire of skills and dispositions. Among these are cognitive flexibility, the ability to consolidate and co-create knowledge, and creative problem-solving. This shift reflects a broader transformation in educational philosophy: from the traditional notion of the "educated person" to that of a "culturally engaged individual." Such an individual integrates diverse, and often conflicting, cultural perspectives into their thinking and actions. Because these perspectives differ in values, methodologies, and worldviews, their integration requires a fundamental rethinking of educational content and structure (Bibler, 1991).

In response to this paradigm shift, teacher education should be reimagined to prepare educators who are not only well-versed in disciplinary knowledge but also culturally responsive, adaptable, and equipped to guide students through the complexities of a pluralistic and dynamic world. Mathematics education—particularly in the domain of geometry—often falls short of these aspirations. School curricula tend to present only finalized, "correct" knowledge, omitting the rich historical debates, conceptual tensions, and alternative frameworks that have shaped the discipline. Textbooks typically emphasize canonical figures such as Pythagoras, Euclid, and Thales, while neglecting foundational yet contested thinkers like Lobachevsky, Riemann, and Bolyai. This linear and distilled approach deprives students of the opportunity to appreciate how mathematical knowledge evolves

through discourse, controversy, and paradigm shifts. In contrast, meaningful learning requires engagement with conceptual tensions and structured frameworks—an approach exemplified by Galileo's *Dialogues* and Newton's geometrically structured *Principia* (Matthews, 2000; Marton, 2015).

Organizing knowledge is essential for fostering deep understanding (Ausubel, 1968). A well-structured presentation of concepts enables learners to recognize connections, grasp underlying principles, and retain information more effectively. It also supports critical thinking by illuminating relationships, hierarchies, and contrasts between ideas. In educational practice, thoughtful organization transforms complex material into coherent, accessible, and intellectually engaging learning experiences.

The Discipline–Culture (DC) paradigm, introduced by Tseitlin and Galili (2005), offers a transformative framework for reimagining science and mathematics education. At its core lies the philosophical concept of ontology, which serves as a bridge between conventional disciplinary knowledge and a more culturally embedded form of understanding—referred to as Cultural Content Knowledge (CCK, Galili, 2012). This ontological foundation can be computationally implemented through Cultural Ontology, which enables structured and meaningful representations of knowledge. The relationship between the DC paradigm and the DC structure lies in the fact that the DC model—characterized by its triadic architecture of Nucleus–Body–Periphery—serves as the concrete structural framework through which the educational principles of the DC paradigm are implemented and represented.

Inspired by data science, the concept of Multi-Viewpoint Ontologies (MVPo), as articulated by Zhitomirsky-Geffet (2022), offers learners multidimensional access to knowledge through hierarchical, visual, and relational structures. In educational contexts, Cultural Ontologies adopt the same structural model as MVPo; however, the term Cultural Ontology emphasizes the unique character of mathematics and science as expressions of DC structure. When scientific theories are organized within this framework and represented through Cultural Ontologies, they promote deeper conceptual clarity, enhance relevance, and foster engagement with diverse mathematical traditions and theoretical perspectives.

In light of the DC paradigm and the current state of mathematics education in Israel, this study investigates how integrating CCK can make mathematics more meaningful and engaging for students, particularly for pre-service mathematics teachers. For many learners, mathematics is perceived as a dry, technical subject studied primarily for its utilitarian applications. However, conceptual understanding goes beyond rote memorization or mechanical procedures. It involves grasping core ideas, enabling the transfer of knowledge to novel scenarios and its adaptation to varied contexts. Rather than accumulating isolated facts or methods, meaningful learning requires organizing knowledge into a coherent structure—one that defines relationships, establishes hierarchies, and ensures validity and reliability.

This research focuses on the development of Cultural Ontology for geometry, grounded in the theoretical framework of the DC paradigm. The pilot study aims to examine the impact of the CCK approach on the teaching of geometry to pre-service mathematics teachers, enriching their conceptual understanding and enhancing their pedagogical practice.

2. BACKGROUND

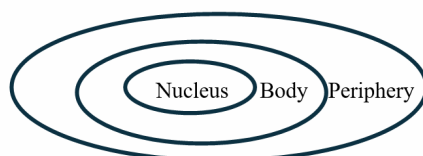
2.1. Discipline–Culture Approach to Subject Matter a Culture of Rules

Our proposal builds on the paradigm of cultural learning, emphasizing plurality of views and conceptual variation within disciplinary knowledge. Such variation reflects the socially developed nature of knowledge, where discourse incorporates diverse meanings and

perspectives. To introduce the cultural aspect while clarifying the status of concepts, Galili and Tseitlin (2005) proposed a special structure for physical theory. A physical theory is seen as an inclusive construct, organizing numerous knowledge elements within a paradigm and domain. They argued that any fundamental theory arranges statements in a centralized structure—nucleus, body, and periphery—forming a quasi-culture.

In this structure (Fig. 1), the nucleus of the theory includes fundamental principles, ontological and epistemological, and the paradigmatic model of the theory. Body elements are all those knowledge elements coherent with the nucleus (theoretical and empirical) and explained by it. The periphery area includes the elements of knowledge in odds with the nucleus (alternative accounts and concepts from other disciplines, old and new, unsolved problems, unexplained phenomena).

Figure 1.
Symbolic representation of areas of knowledge elements within Discipline-Culture
structure of a fundamental theory (Tseitlin & Galili, 2005).



It is the periphery that introduces a dialogue between different theories making disciplinary knowledge cultural. It also makes explicit the limits of validity of the particular theory. Thus, while learning the Newtonian account of motion in mechanics, the students become aware of the alternative concepts of motion in earlier accounts by Aristotle and Philoponus as well as the pertinent ideas from relativistic and quantum theories. This way the considered concepts learned obtain a *space of conceptual variation* essential for meaningful learning (Marton, 2015). Our understanding consolidates in comparison with alternatives, discerning the essence of the concept from the differences. Plurality makes the Discipline-Cultural knowledge more stable and stronger than the pure disciplinary univocal one.

2.2. Cultural Content Knowledge for Geometry

This work introduces Cultural Content Knowledge (Galili, 2012) by presenting a historical and conceptual survey of geometry, tracing its evolution from Euclid's classical foundations to the development of non-Euclidean geometry.

The foundations of classical geometry were laid by the ancient Greek mathematician Euclid (circa 300 BCE) in his seminal work *Elements*. In this treatise, Euclid systematically developed geometry based on five postulates. The first four postulates are intuitive and straightforward, but the fifth—known as the parallel postulate—proved to be far more complex and controversial.

Euclid's fifth postulate can be stated as follows: *If a straight line intersects two other straight lines such that the sum of the interior angles on the same side is less than two right angles, then the two lines, if extended indefinitely, meet on that side.* This formulation is less elegant than the others and appears more like a theorem than a fundamental axiom. Over time, many mathematicians attempted to prove the fifth postulate using only the other four, believing it to be derivable rather than independent.

An equivalent and more modern formulation was proposed by John Playfair (1748–1819) *Given a line and a point not on it, there exists exactly one line through the point that does not intersect the given line*. This version became widely accepted and is often used in contemporary discussions of Euclidean geometry.

During the 18th and early 19th centuries, numerous efforts were made to prove the parallel postulate. Girolamo Saccheri (1667–1733) made significant progress by exploring the consequences of denying the postulate. Although he intended to prove its necessity, his work inadvertently laid the groundwork for alternative geometries. His proof contained logical flaws, but it opened the door to new possibilities (Kline, 1985).

Carl Friedrich Gauss (1777–1855), one of the greatest mathematicians of all time, independently discovered the principles of non-Euclidean geometry. However, fearing backlash from the mathematical establishment, he chose not to publish his findings. It was left to two bold thinkers—Nikolai Lobachevsky (1793–1856) in Russia and János Bolyai (1802–1860) in Hungary—to formally develop and publish the first non-Euclidean geometry, now known as hyperbolic geometry. Lobachevsky published his work in 1825, and Bolyai followed in 1832 (Kline, 1985).

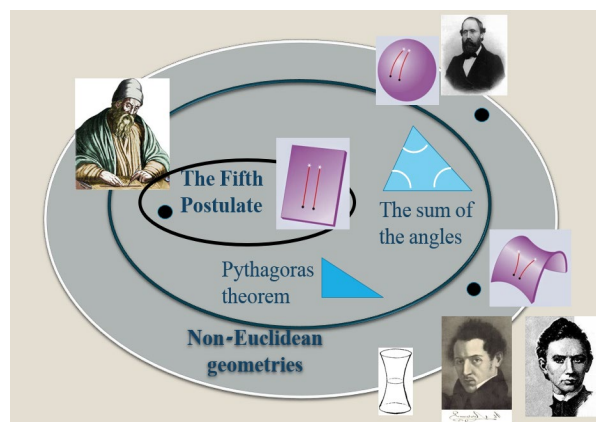
In hyperbolic geometry, the parallel postulate is replaced with the assertion that: *Given a line and a point not on it, there exist at least two distinct lines through the point that do not intersect the given line*. This radical departure from Euclidean principles led to a consistent and coherent geometric system. Eventually, models of hyperbolic geometry were constructed within Euclidean geometry itself, demonstrating that its consistency is equivalent to that of Euclidean geometry.

Later, Georg Friedrich Riemann (1826–1866), a student of Gauss, introduced another form of non-Euclidean geometry—spherical or elliptic geometry—in which all lines (great circles) intersect. Riemann's work extended the concept of geometry to curved surfaces and laid the foundation for Riemannian geometry, a general framework that encompasses Euclidean, hyperbolic, and spherical geometries as special cases (Kline, 1985).

Riemann's insights were revolutionary, influencing not only pure mathematics but also theoretical physics. His geometric framework became a cornerstone of Einstein's general theory of relativity, where the curvature of spacetime replaces the flatness assumed in Euclidean geometry.

The data can be presented in the form of DC structure in the following Figure 2.

Figure 2.
DC of Euclidean geometry vs Non-Euclidean geometries.



2.3. Curricular Infrastructure based on Cultural Ontology

In the field of Information Science, scholars increasingly emphasize the need to design knowledge systems that are not only logically coherent but also ethically inclusive. This dual focus is particularly critical in contexts where diverse perspectives and conflicting viewpoints coexist. Within this discourse, Cultural Ontology emerges as a structured representation of mathematical knowledge that integrates both consensual and culturally specific elements. It functions simultaneously as a formal framework and a pedagogical tool, enabling the organization, comparison, and contextualization of concepts across different mathematical traditions. Such an approach enriches the learning process by highlighting connections and contrasts between ideas, thereby fostering deeper understanding.

Zhitomirsky-Geffet and Avidan (2022) advance this vision by proposing a framework for systematically identifying and classifying inconsistencies in Multi-Viewpoint Ontologies (MVPo). Their model, grounded in description logic and set theory, analyzes eight logical structures of ontological statements and applies them to case studies in nutrition and geometry. Findings reveal that inconsistencies often arise from three recurring structures (S2, S3, S5). To address these, the authors introduce the concept of a “validity scope,” a contextual domain—whether theoretical, demographic, or situational—within which each statement holds true. This innovation allows heterogeneous knowledge to be integrated into a logically consistent system, with practical implications for intelligent applications such as decision-support tools and semantic search engines.

Parallel to this, the CLARE framework for climate-resilient development (Cochrane et al., 2023) outlines five functional areas: research collaboration, knowledge management, monitoring and learning, research uptake, and adaptive management. By emphasizing integrated implementation, CLARE fosters continuous learning, adaptive responsiveness, and effective impact measurement. These principles resonate strongly with the dynamic nature of multi-perspective knowledge systems, underscoring the importance of flexibility and inclusivity.

Ethical dimensions are further explored in Zhitomirsky-Geffet’s (2022) care ethics-based framework for evaluating multi-perspective knowledge organization systems. This model introduces criteria such as viewpoint identification, fair representation, ethical tagging, transparency, and moral balance. A complementary framework (Zhitomirsky-Geffet & Hajibayova, 2020) expands on these ideas by incorporating ethical-logical principles, advocating transparent classification logic and moral integration of diverse perspectives. Together, these models challenge traditional notions of neutrality in information systems and promote human-centered approaches.

Finally, Zhitomirsky-Geffet and Avidan (2022) present a two-phase crowdsourcing methodology for constructing multiviewpoint ontologies. Experts first extract scientific content, followed by non-expert participants classifying 750 statements as true, opinion, or error. Remarkably, participants achieved over 90% accuracy by evaluating what others might think rather than expressing personal views. This demonstrates the potential of structured collective intelligence in building robust, inclusive ontologies.

Collectively, these studies contribute to a unified vision for future knowledge systems—one that integrates logical rigor, ethical responsibility, and participatory inclusivity. Within mathematics education, MVPo as Cultural Ontology exemplifies how thoughtful knowledge organization enhances meaningful learning, supports critical thinking, and makes complex material more coherent and accessible.

3. RESEARCH

3.1. Research Design and Methods

This study applies the Discipline–Culture (DC) paradigm to the teaching of geometry in schools, examining both Euclidean and non-Euclidean traditions through a triadic framework of nucleus, body, and periphery. While the nucleus varies across traditions, its shared pedagogical goal is to foster conceptual understanding by comparing core knowledge with peripheral alternatives. The project includes four components. First, instructional materials are developed, grounded in the DC paradigm and Cultural Ontology, to enhance students' comprehension of geometrical concepts. Second, a course is designed for pre-service mathematics teachers, introducing them to the DC paradigm, cultural ontology construction, and strategies for teaching geometry through this lens. Third, pilot teacher training programs are conducted in colleges of education, integrating the DC paradigm into teacher preparation and evaluating its effectiveness. Finally, assessment tools are created to measure the quality and impact of instructional materials and ontologies, focusing on their contribution to conceptual understanding among pre-service teachers.

3.2. Research Questions

The study is guided by the following research questions:

1. To what extent does the DC paradigm promote conceptual understanding in geometry?
2. What is the quality of conceptual understanding of geometrical concepts as facilitated by the DC paradigm?
3. How do pre-service high school mathematics teachers' views on the nature of the knowledge they learn evolve through engagement with cultural content knowledge?

These questions aim to explore both the theoretical and practical implications of applying the DC paradigm to mathematics education, particularly in the context of geometry.

3.3. Methodology

This study employs a mixed-methods approach through triangulation analysis, integrating qualitative research, ontology construction, and the historical analysis of mathematics.

3.3.1. Empirical Data Collection and Analysis

This research adopts a qualitative methodology, grounded in criteria-focused patterns that emphasize analytical rigor over intuitive interpretation. Researchers rely on a system of external criteria—such as theoretical frameworks, guiding principles, and categorical structures—throughout the study. While this approach shares certain features with positivistic traditions in quantitative research, it remains distinct in its philosophical orientation and interpretive depth (Shkedi, 2011).

The criteria-based methodology integrates both analytical and impressionistic resources. Within the qualitative paradigm, researchers aim to articulate phenomena in verbal and conceptual terms, often engaging with philosophical dimensions of meaning. This methodological framework includes all the core components characteristic of qualitative inquiry, as outlined by Shkedi (2011), and supports a nuanced exploration of educational phenomena through culturally and epistemologically informed lenses.

3.3.2. Cultural Ontology Construction

This study introduces a methodology for constructing a cultural ontology in geometry, grounded in the Discipline–Culture (DC) structure proposed by Galili and Tseitlin (2005). The central aim is to represent disciplinary knowledge in a way that integrates both consensual and culturally diverse elements, thereby promoting deeper understanding through comparative analysis.

The first phase involves the construction of Single-Theory Ontologies. Using formal structures such as OMDoc (Lange, 2013), each ontology is built around a nucleus, representing the foundational principles of the theory, and a body, comprising concepts derived from the nucleus. Semantic relationships—including hierarchy, inclusion, and entailment—define the connections between concepts, while each element is annotated according to its structural role within the theory.

The second phase focuses on the Integration of Cultural and Peripheral Knowledge. Ontologies are expanded to include peripheral elements, with shared concepts across theories marked as consensual and theory-specific elements labeled cultural. This distinction reflects historical, epistemological, and sociocultural contexts. To account for varying conditions of validity, a new ontological class—Validity Scope—is introduced (Zhitomirsky-Geffet, 2019; Zhitomirsky-Geffet & Avidan, 2022). Each theory is linked to a specific scope, allowing knowledge to be represented as context-dependent.

The resulting Cultural Ontology provides a formal structure of geometric knowledge that incorporates consensual and cultural elements, inter-theory relationships, and contextual validity. This model advances the DC paradigm’s goal of fostering meaningful learning by presenting mathematics as a dynamic, culturally embedded discipline.

3.4. Empirical Settings and Results

3.4.1. First Stage Questionnaire

Eight third-year undergraduates in Achva Academic College, Israel —future junior high mathematics teachers—were asked to define mathematical contexts shared by mathematics and physics (e.g., derivatives), contexts relevant only to one discipline (e.g., irrationality in mathematics), and content lacking consensus across different mathematical theories (e.g., parallel lines). The answers they provide show that there was no awareness of the plurality of mathematical theories, variation of definitions and diachronic discourse.

3.4.2. Second Stage Learning

1) Eight third-year undergraduates learned about various historical definitions of the concept of angles (Barabash, 2016) and how these definitions influence current mathematics curricula and textbooks at all school levels.

2) They were introduced to the DC paradigm and CCK examples (Galili, 2014; Vinitsky-Pinsky & Galili, 2014a, 2014b; Levriani et al., 2014; Vinitsky-Pinsky et al., 2025b).

3) They were introduced to the network of inter-linked cultural ontologies (NCO), especially the example of geometry ontology developed by their lecturer (Zhitomirsky-Geffet, 2019). The lecturer had to write a reflection on the process she was going through with students. The students were surprised since they were used to a polyphonic representation of the disciplinary content.

3.4.3. Third Stage Implementation

Eight third-year undergraduates were asked to apply the knowledge they were exposed to by doing a summary assignment in the course. The final assignment involved expanding a Cultural Ontology in geometry by constructing the section on Spherical Geometry. Building on the existing framework of Euclidean, Synthetic, and Lobachevskian Geometry, the task required identifying fundamental concepts of Spherical Geometry, documenting its axioms, and comparing propositions across different geometries. Specifically, we analyzed which propositions hold in both Synthetic and Spherical Geometry, which are exclusive to each, and explored logical relationships such as “derives-from,” inclusion, and overlap. This process deepened our understanding of how geometric systems differ and relate, and helped develop a structured, comparative approach to teaching geometry through conceptual and cultural perspectives.

The students were divided into three work groups for this assignment, with group sizes of 3, 3, and 2 (Vinitsky-Pinsky et. al, 2025a). All the groups successfully completed the task, though they noted that it posed significant challenges from a mathematical perspective. To overcome these difficulties, they frequently consulted a variety of academic sources. Figure 3 demonstrates the comparison suggested by Work Group number 2.

The students' performance in this assignment highlighted how DC-based materials foster dialogue between ideas, encouraging learners to engage in the discourse of geometric knowledge.

Figure 3.
Group 2, Euclidean Geometry vs. Spherical Geometry.

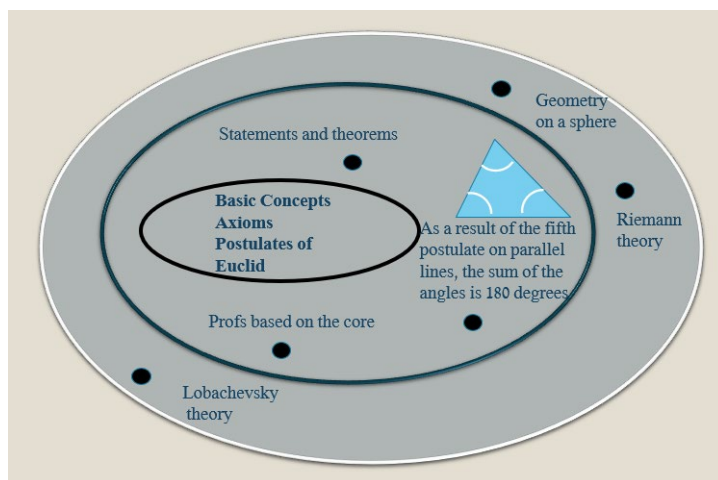
Aspect	Euclidean Geometry	Spherical Geometry
Fundamental Concepts	Point, line, segment, angle, circle, congruence	Point, great circles, arcs, angle, congruence
Axioms	Includes the Parallel Postulate	No parallel arcs; infinite perpendiculars
Triangle Angle Sum	Exactly 180°	Greater than 180°
Congruence Theorems	SAS, ASA, SSS	SAS, ASA, SSS, AAA
Similarity	Similar triangles may not be congruent	No similar triangles—only congruent
Betweenness	Defined: one point lies between two others	Undefined
Simplest Polygon	Triangle	Digon (2 sides)

Below is an explanation from one of the students about how they utilized the DC structure to organize their understanding:

“We can organize the knowledge for the students in the way that when they learn something new (a definition or theorem) we check where it is placed (in DC) and understand how it is connected to the principles.... If we change a definition of a principle we get another geometry – Non-Euclidean...” (participant 1)

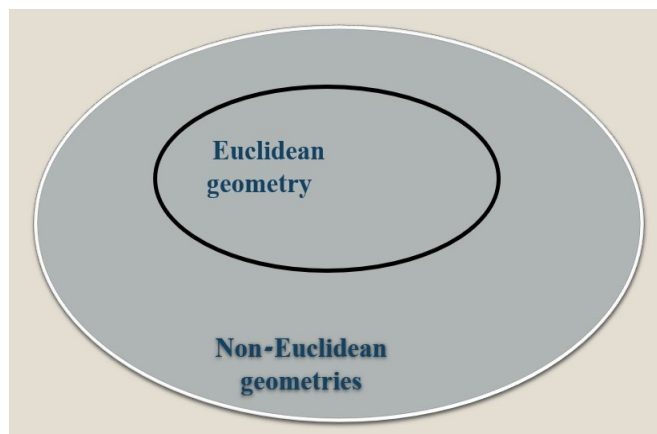
“The nucleus-basic concepts of the Euclidean geometry. The body – sum of triangle angles 180 degrees. The periphery - spherical geometry, “Riemannian geometry...” (participant 5, Figure 4)

Figure 4.
Participant 5, DC-structure of geometry.



Of the eight participants, only one did not successfully represent the DC framework; as illustrated in Figure 5, the body was omitted.

Figure 5.
Participant 8, DC-structure of geometry.



Correct answers and successful performance on the assignment reflect the pre-service teachers' growing conceptual understanding of geometry. The Cultural Ontology, grounded in diverse theories and approaches, exposed them to multiple definitions and connections across Euclidean, hyperbolic, and spherical geometries. These differences, together with the hierarchical structure of the discipline, became visible through the ontology database. Based on their responses, pre-service teachers experienced a noticeable shift in how they perceived the nature of mathematical knowledge.

For instance, when teaching parallel lines, the Cultural Ontology framework allowed Euclid's postulate to be presented alongside its alternatives in non-Euclidean systems. This comparative approach encouraged students to reflect on underlying assumptions and deepened their appreciation of mathematical reasoning. The lecturer observed that once students began constructing the ontology themselves, their engagement increased significantly. Initially hesitant, they gradually embraced the complexity of comparing geometrical systems and started asking profound questions about mathematical truth. Their reflections revealed an emerging awareness of mathematics as dialogical and culturally situated.

This study demonstrates that integrating the Discipline–Culture paradigm with Cultural Ontology construction enhances conceptual understanding by encouraging students to view mathematics not as static truths but as a dynamic, culturally embedded discipline. Building and comparing ontologies functioned both as a pedagogical strategy and a reflective tool, enabling participants to articulate epistemological distinctions and reconsider assumptions. These findings suggest that embedding cultural and historical perspectives into teacher education fosters deeper learning and prepares future educators to teach mathematics with greater clarity and cultural awareness.

The Linking Research Questions to Data and Findings are presented in Table 1.

Table 1.
Linking Research Questions to Data and Findings.

Research Question	Type of Data Presented	Key Findings	Insights
1. To what extent does the DC paradigm promote conceptual understanding in geometry?	Final assignments, ontology construction, geometry comparisons	Students identified differences between geometries, classified concepts using the DC structure, and explained interconnections	Demonstrated deep conceptual understanding through structured knowledge organization and comparative analysis
2. What is the quality of conceptual understanding of geometrical concepts as facilitated by the DC paradigm?	Reflections, group work, student quotes	Some participants articulated distinctions between systems and axioms; others struggled with epistemological complexity	Revealed a range of understanding levels, with a shift from procedural to structural thinking
3. How do pre-service teachers' views on the nature of mathematical knowledge evolve through engagement with Cultural Content Knowledge?	Reactions to historical content, exposure to polyphonic representations	Students expressed surprise and curiosity, recognizing mathematics as culturally embedded and dynamic	Shifted from viewing math as fixed and universal to seeing it as pluralistic and evolving

4. FUTURE RESEARCH DIRECTIONS

The findings of this study highlight several promising directions for future research in mathematics education, particularly in preparing teachers. First, exploring ontological thinking in teacher training may reveal how engagement with cultural ontologies enhances

conceptual flexibility and pedagogical strategies. Longitudinal studies could show whether such exposure leads to lasting changes in teaching practices and curriculum design. Second, integrating mathematics and physics offers opportunities to present cohesive, culturally enriched content, addressing gaps in awareness of shared and divergent contexts. Third, students' surprise at polyphonic representations suggests investigating how multiple voices in curricula influence engagement and critical thinking. Finally, research on scalability could extend cultural ontologies to algebra, calculus, and diverse contexts.

5. CONCLUSION

Although the mathematical component of the course presented a significant challenge, the pre-service teachers gained substantial pedagogical and conceptual benefits from the training grounded in the Discipline–Culture paradigm.

The unique contribution of this chapter lies in its integration of philosophical theory, formal knowledge representation, and practical pedagogy. By bridging Cultural Ontology with teacher education, it offers a replicable model for fostering epistemological awareness and conceptual depth in mathematics instruction.

First, that pre-service teachers engaged in an open-minded, culturally enriched learning environment that contextualized knowledge, enabling them to see the broader picture and recognize practical applications of theoretical concepts across related theories.

Second, through ontology mining, they explored both intra- and inter-disciplinary connections, deepening their understanding of theoretical foundations, historical development, and cross-theory relationships.

Third, exposure to a variety of theories and perspectives allowed them to appreciate the underlying reasons for similarities and differences among theories, fostering a more nuanced and critical view of mathematical knowledge.

Finally, the integration of Cultural Content Knowledge into mathematical instruction empowered pre-service teachers to design learning experiences that are both inclusive and contextually responsive. By exploring the diverse historical trajectories and epistemological foundations of mathematical thought, they cultivated the ability to teach mathematics in ways that move beyond mere procedural fluency—toward deeper conceptual understanding and cultural relevance. This pedagogical evolution reflects a broader shift in educational philosophy: from the static ideal of the “educated person” to the more dynamic and adaptive concept of the “culturally engaged individual.” Such individuals are not only informed but also attuned to the complexities of cultural diversity, capable of integrating multiple perspectives into their thinking and practice within an increasingly interconnected world.

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Chapter # 7

ADULT EDUCATION AND TRAINING IN LATVIA: Case study of the Zemgale planning region

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ABSTRACT

Adult education and training are vital in a postmodern society; they allow not only to improve an individual's personality but also to maintain competitiveness in the labour market. The research aim is to explore issues and solutions in adult education and training within the Zemgale planning region in Latvia. The research concludes that the most widespread problem in adult education and training is a lack of strategy at all responsible levels, with main issues including coordination deficiencies among providers, difficulties in reaching the target audience due to logistical matters, and insufficient resources allocated to adult education and training. The results indicate that municipalities display significantly different models in the planning and organization of adult education and training processes, which leads to suboptimal use of local institutions for promoting adult education and training availability and long-term unbalanced approaches to adult education and training policy and management by sectors and regions, including the planning and implementation of European Union resource grants by state institutions not delegated to planning regions and municipal NGOs. The proposed solutions include better coordination at the regional level, strategic planning, and investment in adult education and training resources, as well as innovative approaches to engaging the community.

Keywords: adult education and training, adult education and training problems and solutions.

1. INTRODUCTION -THE IMPORTANCE OF ADULT EDUCATION AND TRAINING

The time has come when adult learning is a very important social and economic factor in a person's life, as indicated by one of the research topics (European Commission, 2018). This factor is also very important for the social and economic development of local communities, municipalities, regions and countries.

Continuous learning can help citizens cope with future challenges, master the opportunities provided by digital challenges and join the family of European countries, which have provided a place for citizens' education issues and an inclusive society in their planning documents. The situation with citizens' involvement in adult education and training processes is changing, as indicated by the data from surveys and various surveys in Latvia. Adult education and training policy planning documents distinguish between different types of education in which adults can participate, choosing it according to the purpose and possibilities. Lifelong education is based on a person's internal need and the necessity caused by external factors to acquire or supplement their knowledge base or develop skills. In the era of high technology and rapid development of science and technology, knowledge once acquired quickly becomes outdated. Purposefully planned education allows an individual to

constantly improve their qualifications or even re-qualify, if such an opportunity is offered, and the learner can use a specific offer.

Within the framework of the research, the authors define adult education and training as follows: “Adult education and training is a diverse process of educating individuals that ensures personal development and competitiveness in the labour market throughout a person’s life” (Nacionāla enciklopēdija, 2022). Adult education and training refer to a diverse educational process for individuals aged 25 to 64, which ensures personal development and competitiveness in the labour market (Centrālā statistikas pārvalde, 2023). This age is marked by active work, when an adult must engage in economic activities, without excluding the possibility of being socially active, getting involved in shaping the life of the community, society and the state, as well as taking care of their emotional, spiritual and mental health. The EU uses the term “adult education and training” in connection with the fundamental articles of the Maastricht Treaty. This emphasizes the importance of teaching and vocational education beyond general education. Adult education is one way to address current and future challenges. Adult education must be developed and improved to enhance democracy, social solidarity and ecological transformation (Nuissl, Sava, & Farkas, 2024). Adult education can also continue or extend initial education obtained at a general education or vocational education institution, or at a higher education institution. Adult education and training are a process that aims to promote lifelong learning for all, as well as effective learning throughout life (to rise achievement in basic skills, professional qualification, employment training and informal education) to acquire civic, social, moral and cultural attitudes and skills for the performance of duties and progress in all areas of life (UNESCO Institute for Lifelong Learning, 2023; <https://eurydice.eacea.ec.europa.eu>).

In Latvia, adult education and training are organized in the formal and non-formal further education system, also providing for informal learning as an educational process, within which knowledge, competences, skills and values are acquired from everyday and work experience, which improve every individual. Unlike formal and non-formal education, informal learning is not included in the framework of a program or course. According to Articles 36 and 46 of the Education Law, adult education and training can be implemented in formal and non-formal education programs. The procedure for implementing formal adult education programs is determined by the norms of the Education Law, the Vocational Education Law and the Higher Education Law. Although all these laws stipulate the regulated activities of adult education and lifelong learning, the Adult Education Law is missing, which was being prepared some time ago and which would allow stipulating and regulating the norms of the law in one document (Izglītības likums, 1998).

Considering the goals set by the European Union for the involvement of many participants in adult education and training, the authors believe that Latvia has not fulfilled its task - there is no umbrella law (Adult Education Law) in place, which would allow for a systematic organization of the situation in each Latvian municipality. Each municipality differs in terms of the organization of adult education and training, accessibility and support in this field. Consequently, the coordination of adult educators in each municipality differs, which does not allow everyone interested to develop and engage in lifelong learning evenly. In addition, interest and understanding of the issue of lifelong education on the part of the population prevent improving the involvement of learners in the formal, non-formal, or informal learning process. There is also an issue regarding the financial aspect, accessibility in terms of distance to the place of learning, and the availability of tools for a quality learning process. Thus, adult education and training means processes, structures and institutions that are created to promote and implement adult education and training.

The research aim is to explore issues and solutions in adult education and training within the Zemgale planning region, to develop proposals for improving adult education and training from the perspective of stakeholders.

The research questions raised in the article: what are the main social agents or stakeholders providing adult education and training? What are the main problems in adult education and training in Latvia and specifically in the Zemgale region? What are the current and necessary solutions from the perspective of the stakeholders to improve adult education and training in the Zemgale Planning Region?

There are five planning regions in Latvia. Zemgale Planning Region is located in the central part of Latvia and borders all other planning regions. In general, adult education and training in the regions of Latvia is organized in a similar way as in Zemgale.

2. SOCIAL AGENTS INVOLVED IN ADULT EDUCATION AND TRAINING

Stakeholder theory refers to a very broad set of groups, institutions, and individuals who are involved or have been involved in some way or are interested in the course of events or a process and want to steer it in their desired direction. The stakeholder approach allows for both conflict resolution and social tension reduction and can promote better cooperation and mutual understanding (Freeman, 2010; Pesqueux, 2005).

In Latvia, a few stakeholders interact in the field of adult education and training. The Department of Vocational and Adult Education of the Ministry of Education and Science develops policy, organizes and monitors the implementation of policy in the field of vocational education and adult education and training, as well as, in accordance with the competence of the department, exercises subordination over the institutions subordinate to the ministry: the State Education Content Centre, the State Education Quality Service and the State Education Development Agency. When examining the stakeholders involved in the regulatory framework, adult education and training implementers and policy implementers should be highlighted, who, by involving a part of society in educational processes, represent residents over the age of 25 and interested parties who want to obtain education for self-improvement to resolve employment issues, driven by the need for community growth or driven by interest.

The stakeholders can be divided into three levels according to the scale of their functioning, power and influence: firstly, the state or national level stakeholder; secondly, the regional level stakeholder and the local level stakeholder. These levels indicate the context at which the parties involved operate. As a result of the analysis of empirical data, a typology of parties involved has been created, consisting of seven types, and they are: policy makers and policy adopters; policy implementers; educational institutions; day centres, libraries, etc.; NGOs and their networks; entrepreneurs; individuals. For each party involved, its main functions have been considered, with the exception of municipalities, which are implementers of both national and local policies. An increasingly broader range of different stakeholders is involved in the teaching and learning process: non-governmental organisations, the private sector, various social groups, etc., to offer diverse learning opportunities, content and approaches, resources and technologies. Thus, new partnerships, networks and forms of cooperation are being formed between educational institutions and other parties involved, between the public and private sectors. An essential factor in this regard is targeted cooperation between general, vocational and higher education institutions, including by developing shared resources.

3. RESEARCH METHODOLOGY

The authors have chosen a qualitative research approach as their research approach, using semi-structured interviews and focus group discussion methods.

Semi-structured interviews are effective when the research objectives include exploring diverse perspectives, identifying patterns and themes, and gaining insight into individuals' thoughts and emotions. In addition, this approach is valuable when researchers are seeking to establish connections and build collaborative relationships with participants, as it allows for meaningful and interactive conversations. The use of semi-structured interviews allows researchers to explore the wealth of participants' experiences while maintaining the versatility and adaptability of data collection (Salomao, 2023).

Fieldwork was conducted in March and April 2024, implementing a purposeful selection of available informants. 8 interviews were conducted both in person and online. Research ethics were observed during the interviews; all mentioned informants were informed about the objectives of the study and agreed to participate; there was no coercion in recruitment, the right to withdraw, data confidentiality, etc. Interviews were conducted with the Chairman of the Board of the Latvian Adult Education Association, a representative of the Zemgale Planning Region, and implementers of Adult Education and Training policy in the municipalities of Zemgale - Aizkraukle, Bauska, Dobele, Jelgava - and the municipalities and policy implementers of Jekabpils municipalities and the city of Jelgava. During the interviews, it was possible to obtain information from specialists in municipalities responsible for adult education and training issues. The answers from the informants provided insight into how issues regarding adult education are organized in each municipality, how many employees are employed on this issue, what issues they are entrusted with, what target groups are worked with in the field of adult education and training, and what resources - municipal, state or EU funds - are attracted to address adult education and training issues.

On April 2, 2024, 2 focus group interviews (average length 30 minutes) were held at the Dobele Adult Education and Entrepreneurship Support Centre (PIUAC) with learners about adult involvement in educational processes and obstacles that hinder it. The first focus group had 9 participants and the second had 12 and were selected using a purposive sampling method, informants represented a diversity of viewpoints. The main target groups of learners are employees of local governments and their institutions, entrepreneurs, working and unemployed people or job seekers, and seniors. In the focus group interviews, the informants focused on outlining personal experiences. The participants did not express their views on adult problems in general in the country or region, but expressed a vision based on their personal experience, which also allows the research to understand specific nuances faced by those involved in adult education and training.

4. CASE STUDY OF THE ZEMGALE PLANNING REGION

4.1. Key Stakeholders in Adult Education and Training

Each stakeholder has its main functions taken into account, with the exception of municipalities, which are both national and local policy implementers. Adult education and training activities in the municipalities of the Zemgale planning region are implemented in three ways: through Registered Learning Centres (Jelgava City Municipality and Dobele and Aizkraukle municipalities), through Lifelong Learning Centres (Jelgava Municipality) and education specialists in municipalities (Bauska and Jēkabpils Municipality). There are great differences between adult education and training centres, each of which has its own way and

model of organizing adult education and training in its municipality. Here, we should also mention differences in the territorial sense, where the territory of a Latvian state city differs from the territory of a municipality, which often combines several cities, villages and parishes (the problem is the accessibility of the population in terms of distance). Adult education and training centres have been reorganized over time, creating different models. For example, in some municipalities, this task is delegated to the Education Board or the Education Department.

Even though there are various examples of cooperation, for example, between municipalities and educational institutions, a coordinated approach that would bring together different agents and resources in the field of adult education and training is often missing. Funding is one of the main problems, especially in relation to the need for new educational projects and the development of programs.

4.2. The Main Problems in Adult Education and Training

A problem that affects not only Latvia is the number of adults with low levels of digital skills or no digital skills at all. Education and Training Monitor in 2024 shows that only 51% of the adult population (16-74 years) in Latvia possesses basic digital skills. This places Latvia significantly below the EU average. The question is about the accessibility of these residents, both in terms of information transfer and education: initially, these residents must be motivated to engage in learning, because without motivation and a clear goal, why do I need it? - It will not be possible to involve these residents in any AE processes. Unfortunately, studies have proven that people with an initially lower level of education, without education, the unemployed, and seniors are reluctant to resume or start education (Laskova & Brokane, 2013; Education and Training Monitor 2024).

The absence of a single institution responsible for adult education and training as a whole is mentioned as a problem in Latvia. *"We do not have a law on adult education, and therefore these responsibilities are split: adult education and training is dealt with by the Ministry of Economics, and in some way by the Ministry of Education and Science, and in some way by the Ministry of Regional Development, Regional Planning and Regional Development, and municipalities"* (Head of the Lifelong Education Department of Jelgava Municipality). The interviews revealed a very different picture in each municipality of Zemgale, where the authors of the paper conducted interviews. The Zemgale planning region includes 6 municipalities with 5 counties and 1 city of national importance. In each municipality, the provision of adult education and training has been organized very differently over the past 20 years. If in one of the municipalities it is maintained and developed in the form of adult education and training centers, then in another, the workload of the adult education coordinator is included with a very small % in the workload of some other position.

The analysis of interviews with stakeholders suggests that the biggest challenge for adult education and training policy makers and educators in regions and municipalities is to address the issue of greater citizen involvement in adult education and training, using all available tools and instruments. The advantage of engaging lower-paid and less educated citizens in learning processes lies with the organizers of adult education and training processes in local municipalities, as personal approach, feelings of security, presence and proximity to educational processes will lead to greater involvement in lifelong learning processes in every municipality and region. Summarizing what the informants said, a lack of resources has been identified, both in terms of staff fully dedicated to adult education and training and financial resources specifically allocated to adult education and training initiatives. However, problems such as long distances in the region and transport problems

significantly hinder participation and involvement in adult education.

“... my vision and experience - smart are those municipalities that provide and establish an adult education and training center, because it is a tool by which the municipality can achieve and promote all its strategic development plans, because the basis of the development of all things is education and information”. Those involved in adult education and training from the local government side face problems in transferring information to their existing and potential clients daily. The closure of printed newspapers, the lack of computer skills and technical support do not contribute to obtaining information for improving one's knowledge. The focus group participants highlighted a similar problem from the client side - the lack of information in the adult education and training offer. At the Dobeles PIUAC, where two focus groups were interviewed about adult education and training problems, the emphasis was placed directly on the inaccessibility of information. The cooperation of adult educators in the Dobeles region as a network has not been established; here, the centre's activities are focused on Dobeles and Auce, where two training specialists work. As the representative of the Jelgava region municipality mentioned in the interview, the coordinator's duty in each parish is to inform their residents about adult education and training activities in the region. The head of the lifelong learning centre also emphasized the adult education and training culture as a problem, as non-existent, on which Latvia still needs to work very hard and diligently. Informants point out several important aspects in their responses to the problems. For example, coordination between all parties involved in adult education and training should be improved, possibly with the leadership of the Zemgale Planning Region. This includes the creation of cooperation networks and, possibly, a dedicated position or team responsible for the development and monitoring of adult education and training throughout the region.

Table 1.
Main problems in adult education in Latvia and specifically in the Zemgale Planning Region.

Problem	Solutions	Benefits
Unorganized system at the national level	Development and implementation of the Adult Education Law	Financing of adult education and training in the state and local government budgets in the long term. Development of the adult education and training sector after the end of European Union funds support.
Lack of coordination of adult education and training	Involvement of the Zemgale planning region in the distribution of funding and coordination of adult education and training	A common understanding of adult education and training at all levels: national, regional and local. Attracting funding, for example through various projects, and coordinating its distribution, taking into account the specific needs of the region.
Lack of coordination	Involvement of the Zemgale planning region in the creation of cooperation and the development of adult education and training	The overall development vision of the Zemgale planning region for the development of adult education and training in Zemgale. Cooperation with entrepreneurs to ensure their current needs - by educating the workforce, etc. ensuring professional development. Creation of cooperation networks in each municipality, county and region, involving various interested parties in cooperation.

Problem	Solutions	Benefits
Lack of information	Involvement of all interested agents in the preparation and dissemination of information	Accessibility of adult education and training to everyone interested. Informing employers about opportunities for employees in the field of adult education and training.
Popularization of adult education and training	Popularization of the field of adult education and training at the national level, involving the media	Strengthening the importance of adult education among policy makers, adult education and training implementers, local government representatives and residents. The importance of adult education and training in the field of professional and personal growth among both residents and employers.

Source: Created by the authors based on interview and focus group analysis

The head of the Lifelong Learning Department of the Jelgava Regional Education Board believes that it would not and is not possible to solve national problems at the municipal level; they should be left at the national level, but what the municipal authorities and the specialists working there can do is to directly address the residents *“currently everything is based on personalities; we need a system of coordinators in the country - we need to go to the people. Until there is a culture of lifelong learning in the country, we need to go to the people; otherwise, there will be nothing”*. In turn, representatives of the Dobeles PIUAC and the Jelgava City Council believe that it is very important to work on public relations at both the municipal and national levels, talking about adult education and training, its importance in everyone's life in adulthood, so that a resident in every Latvian parish would think about and consider the need for education even after obtaining formal education (up to the age of 25). Information support is needed at all levels, from the state for popularizing adult education and training to adult education and training implementers in municipalities, so that every citizen has access to information about available educational offers, whether it is formal, non-formal or informal education; it is important to know about accessible, supportive, future-oriented education for adults, organized into a system for long-term operation in the future with clearly identified agents - policy makers, funders, education organizers and learners. *“Well, the biggest challenge was to address people. Of course, as we decided, we put those posters and advertisements on the websites, very beautiful with all the pictures, and beautiful names, and explanation's what those computer courses mean, and how long they will be, and how to apply, and so on... - that poster stood on my website for a month, no calls, no nothing”*.

Focus group participants emphasize that they are happy to spend time in the evenings guided by their interests; in turn, when asked about training for work needs, they emphasize that they would rather attend such training during working hours. Unfortunately, the interest of employees in attending courses during working hours does not always coincide with the opportunities to attend them, especially if these courses offer to study another field that could be useful to residents in the future, for example, when creating their own economic activity. Focus group participants emphasize that it is very important to attend courses and seminars as close as possible to their place of residence. A very important prerequisite is to receive information about possible training offers, and a very important aspect is the financial aspect, although they point out that if this arena of education is of great interest, the financing aspect is not crucial.

5. CONCLUSIONS AND PROPOSALS

For the provision of adult education and training and the involvement of adults in it, it is very important to ensure all possible ways from the state in the development of regulatory enactments, attracting funding and providing adult education and training. A very important factor here is also the involvement of adults themselves, the promotion of a culture of lifelong learning, starting at the national level, and at the very foundation, to highlight the value of education already initially in the family circle. It is important to teach learning by continuing it in the school environment: pre-school, primary school, secondary school and later stages of education. Research has confirmed that lifelong learning of an individual contributes to higher self-esteem, further education for adults and access to adult education and training opportunities for those who have already received a better education initially. At present, it is necessary to stop thinking about a vocational or higher education institution as a final place of education; now society must understand that adult education and lifelong learning are a normal, unchanging dimension of all human life; that is why it is necessary to create an adult education and training system that ensures the transition of adults from youth education to adult education and training.

The Education Law and various policy planning documents regulate adult education and training in Latvia, but they do not ensure a sustainable connection with the parties involved in adult education and the general needs of society.

Participation in adult education and training is determined by several factors, such as previous education, employment status, profession, age and developed skills. Adults with low or no education, low-skilled workers, the unemployed and seniors are reluctant to participate in lifelong learning. Given that adult participation in education processes is often not possible for adults in this category, the goal remains unfulfilled for those who would need these operations the most.

There is cooperation between the various stakeholders, but coordination could be more effective and with a greater role for the Zemgale planning region in coordinating activities in adult education and training.

One of the most important problems is reaching and engaging people in educational activities. Information dissemination methods, such as websites and advertisements in newspapers, often have a low level of effectiveness. Often, a more effective approach is cooperation with libraries, day care centres and direct communication with the target audience.

Projects using European Union funds play a crucial role in providing adult education and training. However, there is a need for more stable and long-term funding sources to ensure the sustainability of adult education and training programmes.

There is no law regulating adult education and training in Latvia; therefore, a sustainable adult education and training system has not been implemented that would define the division of responsibility and coordination between the ministries involved, the financing procedure from the state and local government budgets for the provision of human resources and teaching aids for the long-term development of adult education and training.

In the issue of adult education and training, large differences have been observed between the municipalities of the Zemgale planning region in the understanding of this area and in the provision of adult education and training to improve the skills necessary for residents close to their place of residence. The absence of a system in Latvia in the development of the adult education and training area has not led to the planned development and involvement of residents in adult education and training activities.

The Ministry of Education and Science, as the leading state administrative institution in the fields of education, science, space and sports, as well as in the field of youth and state language policy, must develop an Adult Education Law with a long-term strategy for the formation of adult policy in Latvia, providing for responsibility for the administration of adult education and training, coordination between the ministries involved, the definition of adult education and training priorities and the provision of funding in the state and local government budgets, including monitoring of the effective use of resources.

Planning regions and municipalities, for sustainable access to adult education and training for residents, must establish a coordination and cooperation network, focusing on a balanced sectoral and territorial approach, involving local libraries, educational institutions, day centers and other institutions in the municipality in providing adult education and training.

To solve the problem, the Ministry of Education and Science, when developing the Adult Education Law, should provide for long-term funding in the state and local government budgets, with a defined delegation of tasks for the provision of adult education and training in educational institutions at all levels, also providing for monitoring the quality of adult education and training.

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Chapter # 8

ENTREPRENEURSHIP EDUCATION BY ME & MYCITY PROJECT

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ABSTRACT

This study examines the Me & MyCity learning environment as a pedagogical method for enhancing working-life competencies among Finnish sixth-grade pupils. In Me & MyCity, twelve-year-old students participate in a one-day simulation in a miniature society that includes companies and public services. During the visit, pupils work in assigned roles, earn a virtual salary, and act as active citizens and consumers. The project aims to investigate the learning outcomes and experiences of both teachers and pupils. The research sample consists of 40 teachers, 220 pupils, and an additional group of 70 pupils from Tampere and five surrounding municipalities. The theoretical framework is based on the Finnish Core Curriculum 2016, phenomenon-based learning, Kolb's experiential learning theory, and Strauss's grounded theory approach. Empirical data have been collected through multiple qualitative and quantitative methods. The findings indicate that Me & MyCity is an effective and engaging teaching method that supports pupils' understanding of economic concepts, working life, and entrepreneurship. Pupils enjoy participating in the simulation and value the opportunity to work in a chosen profession. However, teaching materials are perceived as somewhat theoretical, suggesting that more concrete preparatory activities could strengthen learning outcomes.

Keywords: curriculum, working skills, entrepreneurship education, teaching method.

1. INTRODUCTION

Pirkanmaa has about 530,000 inhabitants, with the center being Tampere, which has about 250,000 inhabitants. The pupil learning environment *Me & MyCity Pirkanmaa* is placed in this frame of reference. Pirkanmaa needs more small and medium-sized companies and, above all, growth companies because unemployment has risen at a record pace.

Pirkanmaa's unemployment rate is 12.3 percent in October 2025. According to the final report on entrepreneurship education published by the European Commission (2013), the whole of Europe has not recovered from the economic downturn of 2008 in the desired time. As a medicine, the report proposes promoting and enhancing entrepreneurship education in schools and universities. The same drug is also suitable for the treatment of the COVID-19 pandemic, which was shaking the entire world economy (See: Liguori, E. & Winkler, 2020; Liguori 2018 et; Ratten, 2020). The owners of F-Secure and Supercell in Finland have responded to this challenge by donating EUR 6 million to entrepreneurship education in schools. At the heart of all this is European education and economic policy, which calls for the European Union to become the most competitive and dynamic knowledge-based economy in the world, capable of sustaining economic growth and creating new innovative jobs. European Commission, (2000). Me & MyCity Pirkanmaa is in this frame of reference.

2. ME & MYCITY PIRKANMAA

Me & MyCity is a learning entity for society, working life, and entrepreneurship aimed at the sixth grades of comprehensive school. The visit to Me & MyCity is preceded by a course of about 10 lessons and a complementary visit to the visual village of Me & MyCity. Me & MyCity day is led by educational material on economic issues based on the primary school curriculum. The teaching material covers the following issues: private and public services, job search, various companies, taxes, banking, financial accounting, advertising and customer service, and sustainable development. Me & MyCity operates in 13 locations and reaches 80% of sixth graders in Finland. Every school year, about 50,000 pupils visit Me & MyCity. The concept of Me & MyCity is funded by the Ministry of Education and Culture, foundations, private partners, and municipalities.

The research of Me & MyCity Pirkanmaa has sixteen different business and public service premises as well as City Hall. The learners work in a mobile Me & MyCity built of cardboard elements for the day in the profession they have chosen. The themes of the lessons and the assignments made by the learners in the workbook help the learners perceive their role in Me & MyCity as a n employee and consumer. For learners work, he receives a virtual salary and acts as a consumer and citizen as part of society. Me & MyCity employs about seventy pupils at a time and have supervised by tutors too. Tutors are pupils from a secondary school. The pupil group participates in Me & MyCity Day on a prearranged day from 9.30 AM to 2 PM. Before visiting Me & MyCity, the pupils complete a ten-hour study unit consisting of financial matters. Teacher training and orientation to Me & MyCity take place with a few hours of guidance. The following video gives an idea of Me & MyCity, <https://youtube/Jt-wFB5KZOE>

2.1. Theoretical Background of Me&MyCity

The research framework is based on the Finnish current primary school curricula (POPS, 2016, see Figure 2). At the school level, the school principal leads curriculum work. (See Uljens, & Rajakaltio, 2017) Curriculum work is guided by the Basic Education Act and Government Decree 422/2012. The principal in his or her own school implements the implementation of the curriculum.

Me & MyCity, on the other hand, has been studied quite a bit. Some theses about Me & MyCity have been done, for example, by Lindholm (2017), Roine, (2013), and Ojala (2021). First two mentioned are students seminar papers, not full-time research. Prof. Kalmi at the University of Vaasa has studied how Me & MyCity supports pupils' understanding of financial issues. The study concludes that the understanding of financial skills was significantly improved by 17% for those pupils who had participated in Me& MyCity learning method and all t-values are statistically significant at 1% level. The result was obtained by measuring the knowledgeable level before and after visiting Me & MyCity learning environment. (Kalmi, 2016).

In Finland, phenomenon learning, and its related concept multidisciplinary learning entity (Figure 2) were highlighted in the Opetushallitus (National Board of Education) (POPS 2016). The multidisciplinary learning entity has been justified by POPS, for example, motivation, creating a community culture and working life needs. A multidisciplinary learning entity means learning in which broad thematic entities are outlined across subject boundaries and things are explained by combining different subjects.

Kolb's (1984), experiential learning is seen as a circular cycle and includes unconscious and conscious understanding, as well as four related topics that emphasize learning in different ways. These four groups are direct personal experience, for example, brainstorming

or a learning diary and critical contemplative observation can be used as a teaching method. In the abstract conceptual phase, theories and models structure personal experience, and teaching, group work, or reading can be used as teaching methods. The active model is an experimental activity model tested model and the knowledge is applied in practice through case studies, role-plays, exercises, and on-the-job learning.

The phase of active activities can also take place in the form of a project, where the material to be studied is tested outside a formal learning situation. Kolb's cyclical learning model is suitable for entrepreneurship education because it highlights thinking and learning-to-learn, the pupil's experiences, the uncertainty of experiences. (Kupias, 2001, pp. 16-25; Leppilampi, & Piekkari, 1998, pp. 9-11; Hakkarainen, Bollström-Huttunen, Pyysalo, & Lonka, 2005; Autio, 2006; Seikkula-Leino, 2007, p. 31; Blender, Dreisler, & Kjedsen, 2006, p.101).

Figure 1.
The course of the research.

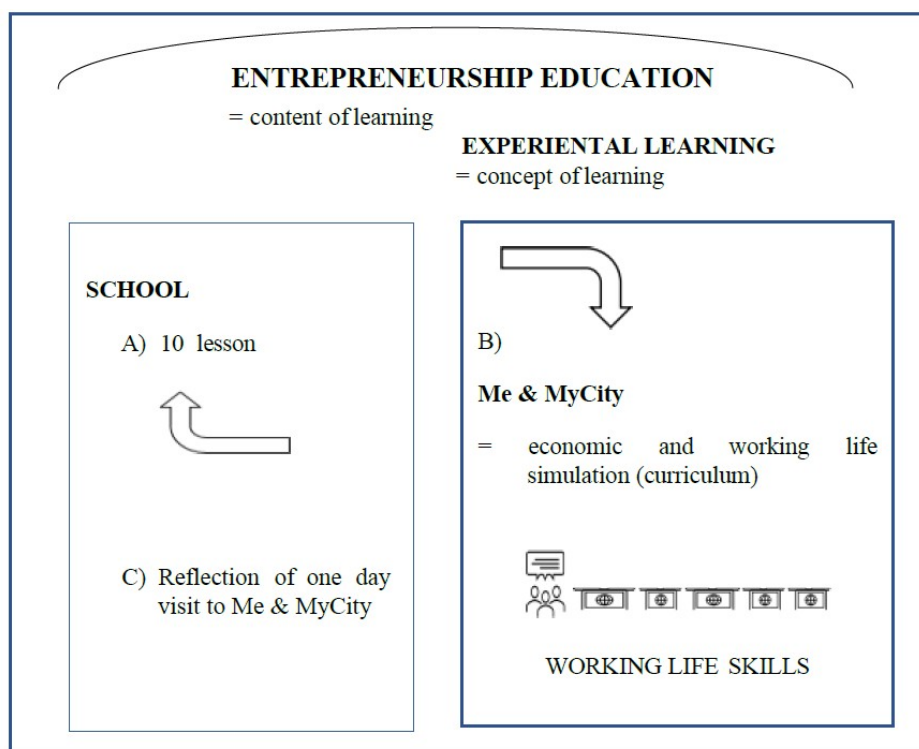


Figure 1 shows the course of the study. First in class 10 lessons are taught in economics according to the curriculum and then the things learned are practiced in a Me & MyCity. Pupils also choose the profession in classroom they will work in Me & My City.

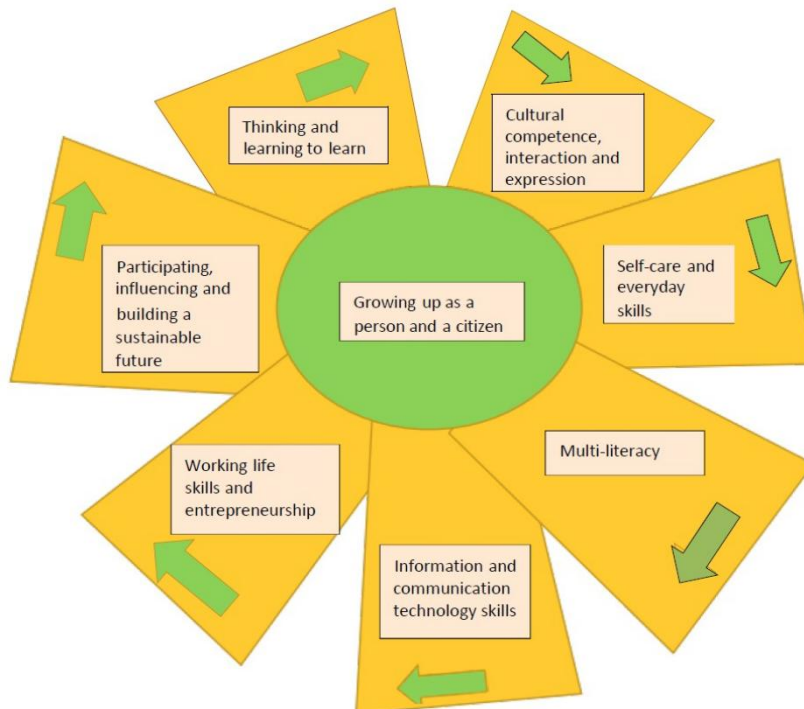
2.2. Extensive Competence in Curricula

The curriculum is difficult to define at a general level because it depends on the perspective into the seven different blocks. (Figure 2) Overall, it is an entity through which

the pupil learns skills and knowledge. The experiential nature of learning is also related to this. Existing aids, such as the development of information technology, also guide the development of the curriculum. (See: Marsh, 2004, pp. 4-7, Autio, 2014). Thinking and learning create the basis for the development of competence. A key role of the teacher is to encourage the learner to be self-confident and critical of knowledge and to guide the learner in independent knowledge acquisition and to encourage the learner to create new knowledge through play, experimental and playful practices, and teaching methods. Each learner is guided to identify their own way of learning and to develop their learning strategies so that they provide a basis for postgraduate study and lifelong learning.

Current curricula present a concept of learning in which the key issues are the pupil's active role in their own learning, interaction and doing together, positive experiences support of motivation, learning to learn skills, and self-direction and its support. Extensive knowledge in Figure 2. (POPS, 2016) refers to the totality of attitudes and will of the values of knowledge and skills. Competence refers to the ability to use knowledge and skills as required by the situation. The need for broad-based expertise arises from the changes in the world around us, and there are a total of seven areas of expertise. Broad-based competences have commonalities and aim to support learner growth, promote membership of a democratic society and competences that require a sustainable lifestyle. It is especially important that the learner recognizes his or her own strengths and weaknesses (POPS, 2016).

Figure 2.
Extensive competence of the comprehensive school curriculum 2016
(Source adapted by Ojala, A. 2021, based on POPS 2016, pp. 20-24).



2.3. Entrepreneurship Education based on the Pupil's Need

Me & MyCity as a learning environment is understood here as a teaching method. The teaching method is the way of teaching and working. It activates and motivates the pupils. A successful teaching method depends on the level, motivation, and habits of the trainees. Experiential and functional ways of working, as well as the use of different senses and movement, increase the vitality of learning and strengthen motivation. Motivation is also strengthened by ways of working that support self-direction. (cf. POPS, 2016) Teaching methods should activate the common learning process. In this method, the actual Me & MyCity day theory part and the pupils' introduction to the concept of Me & MyCity learning environment are taught in Me & MyCity lessons in class. The actual working life skills training then takes place in Me & MyCity (cf. POPS, 2016, pp. 20-24, see also Ranne, 2009).

Entrepreneurship education first appears in Finnish primary school curricula as early as 1994. In 2004 the basic education curricula, entrepreneurship education emphasized the pupil's active role in learning (Lehtonen & Lehtonen, 2011, see also POPS, 2016). Perceptions that support learning form the psychological basis of the learning environment and are inextricably linked to knowledge and the interest in knowledge: How knowledge is used and acquired and how it is analyzed (Lehtonen & Lehtonen, 2011). Entrepreneurship and related education and upbringing are different in different countries and cultures. However, entrepreneurship and entrepreneurial activity are relatively similar in different environments.

In previous studies, it can be stated that entrepreneurship education is an ambiguous term and its definition is difficult (Korhonen, et. al., 2012; Ristimäki, 2011; Katz, 2003; Matley, 2005, 2008; Rae, 2005, Rae, & Carswell, M. 2001, Rae, & Woodier-Harris, 2012; von Graevenitz, & Harhoff, & Weber, R. 2010). A clear definition and understanding of entrepreneurship education has been hampered by partial, conceptual, and contextual confusion, non-theory (Fayolle, 2013), and fragmentation. Entrepreneurship education and entrepreneurial learning have been defined with many different definitions, in broader and narrower versions, mainly in a business environment. Jones, and English (2004) defined entrepreneurship education as skills that can be taught and qualities that enable learners to previous research have shown that entrepreneurship education is an ambiguous term and its definition is difficult (Korhonen, et. al., 2012, Ristimäki, 2011) by researchers (e.g., Fayolle, 2013; Higgins, & Galloway, 2014; Liguori, et al., 2018; Matley, 2005; von Graevenitz, Harhoff, & Weber, 2010).

Today, the development of entrepreneurship education has gradually shifted away from a strictly business and management-focused focus towards a multi-disciplinary approach that brings together different study programs, towards entrepreneurial education based on learner needs, holistic learning (POPS, 2016). It encompasses the natural sciences, technology, as well as the humanities (Wilson, 2008; Heinonen, Hytti, & Tiikkala, 2011). This enables more use of learning challenges and new ways of learning in the learning process, in personalization of learning, utilization of technological applications and simulators in the learning process and, for example, the use of pupils' smartphones in learning. The implementation of entrepreneurship education should include, for example, community, problem-solving, learning from mistakes, team learning, project work, learning by doing, learning diaries, pedagogical drama, training entrepreneurship, as well as getting to know working life and company visits (Seikkula-Leino, 2007, pp. 35-37; Seikkula-Leino, Ruskovaara, Ikävalko, Mattila, & Rytölä, 2012, pp. 117-127; POPS, 2016).

Increasing entrepreneurship in Europe was a key element of the Lisbon Strategy for Growth and Jobs (2001), which aimed to make the European Union the world's largest economic area by 2015. Increasing the number of enterprises was also a key factor in developing the European Economic Area in the Europe 2020 strategy for growth and jobs (European Commission, 2010), which continued the work of Council of the European Union (2005): *The Lisbon Strategy*. To increase the number of companies, the Entrepreneurship 2020 program was launched, one of the main pillars of which was entrepreneurship education (European Commission, 2013). European Commission (2010) says entrepreneurship education should be integrated into all curricula (cf. POPS, 2016, Figure 2). (See also Kalmi, P. et. al. 2015 and 2016).

Policies of the Ministry of Education and Culture on 17 March 2017, the Ministry of Education and Culture published new entrepreneurship guidelines for education (OKM Entrepreneurship Guidelines, 2017), the purpose of which is to guide, develop and guide measures to promote entrepreneurship and entrepreneurship education at different levels.

3. THE RESEARCH TARGET

The research target is Me & MyCity Pirkanmaa, a total of 220 pupils and 40 teachers are involved in the research. Five of the schools are in the vicinity of Tampere: Orivesi, Nokia, Ylöjärvi, Kangasala, Vesilahti and Pirkkala. The neighboring municipalities have been included because in Tampere the curriculum is made regionally and Me & MyCity Pirkanmaa. The research material was collected in 2013–2016 and the additional material in 2019–24. The additional material from 70 pupils has been collected immediately after the visit in Me & MyCity. The additional material also include 10 teachers. The nationwide material is only pupils who were collected intermediately after visit.

3.1. Research Task

1. How do teachers perceive entrepreneurship education and Me & MyCity as a teaching method?
2. How do pupils perceive Me & MyCity as a teaching method?

3.2. Research Analyses

The present research is based on the work of Glaser, and Strauss (1967) and is based on the Straussian orientation, and the Straussian school enables the study problem to be studied existing bringing ready-made categories derived from theory into the analysis process. (See: Glaser, & Strauss, 1967; Glaser, 1992, p. 102, pp. 16-17; Lowe, 1996, p. 2.) When assessing the reliability of the study, the study partly uses the reliability analysis of the Strauss and Corbin schools. (See: Tynjälä, 1991, 1999, , Alasuutari, 1999). Grounded Theory of Strauss & Corbin, J. 1990, does not prohibit the use of previous research in theoretical sampling.

The analysis aims to verify the resulting hypotheses and to understand the relationships and explanations between the concepts through the research material. (Strauss & Corbin, 1994, p. 274.). The purpose of Grounded Theory is to create a theory that explains the phenomenon under study and that is relevant and relevant to the problems involved. The theory is created around the core categories, a teaching method pupils' experiences and teaching method teachers' experiences of Me & MyCity. After the axial coding process, selective coding can be switched. Selective coding is the process of selecting a core category, in which the description of a phenomenon is moved to a conceptual level. The core category

explores several important roles in creating a theory. The core categories are selected as a key phenomenon to which other categories can be associated. These core categories are, Me & MyCity as a teaching method and pupils' experiences of Me & MyCity. The study examines Me & MyCity through two observation units. The maturation of the categories is promoted by theoretical sampling. Theoretical sampling provides a continuous direction for research, as previous research and literature on the subject can be used in research. the relation of other categories to the core category is done through a paradigm: circumstances, context, strategies, and consequences. (Strauss & Corbin, 1990, p.124.).

3.3. The Sample of Open Coding

The coding of the study is based on the Straussian school's view of three different coding levels: open coding, axial coding, and selective coding. The study first modifies qualitative data through meaningful, empirical indicators. This is called open coding. Glaser and Strauss (1967, pp. 101- 102) call this a test of assumption.

Yes, this is PIK1 great for elementary school. Let us learn initiative and work. PIK12 The students noticed from PIK12 my activities that the point would be Me & MyCity hour. They were really looking forward to it. This is great for PI K3 a math section, percentages, and all. However, the learning material was PI K22 a bit challenging. Lot of concepts. I do not know if I got there (P1 stands for person and KI for coding marks).

After this is followed by an axial coding and selective coding. Axial coding is a set of procedures by which categories are linked together by examining the conditions, context, action and interaction strategies, and consequences of a phenomenon. Selective coding, on the other hand, is the process of finding a core category. An analytical account of a core category is a theory that the researcher can report and publish (Strauss & Corbin, 1990, pp. 174-175) However, in developing a theory, attention must be paid to theoretical sampling.

4. RESULTS

4.1. Teachers' Experiences Me&MyCity as Teaching Method

In the interview, the teachers saw Me & MyCity teaching and learning method as strengthening civic skills and pupil co-operation. The visit to Me & MyCity was particularly well suited to the mathematics period, as taxes and percentages were calculated there (cf. POPS, 2016). However, the use of the teaching material was challenging, not everyone had time to go through it in 10 hours. According to the teachers, the pupils learned from each other, and asked help from the adult tutors in Me & MyCity if they could not do some work. Most of them liked the job and knew how to do it. (cf. POPS, 2016) The pupils waited for the visit to Me & MyCity and noticed from the teacher's hourly activities that now the Me & MyCity lesson is coming. The sixth grade was the most appropriate because the pupils saw their role realistically even saving money (Kolb, 1984) although they were aware that virtual money did not work outside Me & MyCity. Pupils also liked the profession they had chosen (POPS, 2016; Kolb, 1984). There were some problems with disciplinary visits to Me & MyCity.

“Sorry, you send false invoices”.

There were also thefts in a few cases. However, the pupils resolved the problem case with each other. The use of computers developed the pupils' initiative, as there were 40 tablet computers in use in Me & MyCity. If necessary, help was received from the Me & MyCity instructors. (Ojala, A. 2021) For developing the teaching method, two visits (spring and autumn) were hoped for. The same was what the pupils wanted. In this way, the learning experience deepens and at least then the students wanted to work in the same profession. (Kolb, D. A. 1984).

4.2. Entrepreneurship Education as Defined by Teachers

Teachers of entrepreneurship education saw it mainly as internal entrepreneurship, as a way of working through the curriculum. (Cf. POPS, 2016) Teachers found a clear link to the curriculum. However, the understanding of entrepreneurship education as fundraising also came to the attention of teachers. There are a lot of sales ancestors in elementary school (class trips).

“Taking personal responsibility for learning and competence through internal entrepreneurship.”

The latter is also very evident in terms of lifelong learning: taking responsibility for learning and competence. Entrepreneurship education is emphasized in all Finnish curricula, and teachers play a key role in how it is implemented in practice. (See: Seikkula-Leino, Ruskovaara, Ikävalko, Mattila, & Rytkölä, 2010); European Commission. 2010). In addition to the above, entrepreneurship education should be linked to the school's operational culture and management strategies.

4.3. Pupils' Experiences of Me & MyCity

Pupils are growing up in a world where they are more concerned with knowledge. The work is based on working together and working in networks. This is precisely the wide-ranging competence that the primary school curriculum (2016) emphasizes. In the interview, the pupils first described the work and the profession they had chosen for their position in Me & MyCity.

“Nice taste of working life.”

Everyone would like to visit again Me & MyCity and most would choose the same profession. (Kolb, 1984), (See: Wilson, 2008; Heinonen, Hytti, & Tiikkala, 2011.). This also supports Kalmis' research, according to which learned financial matters practically closely, earned to save money even though virtual money did not work outside.

“I went to ask for a pay raise No, salaries could not be raised” “I save the money to computer”.

“The virtual card was hard for it when I didn't know how much money was in the account.” (See Kalmi, 2015; Kolb, 1984, pp. 9-11; Hakkarainen, Bollström-Huttunen, Pyysalo, & Lonka, 2005; Hakkarainen, 2009; Autio, 2006; Lehtonen, & Lehtonen, 2011; Leppilampi, & Piekkari, 1998.).

4.4. Discussion and Further Research

In this study, study validity refers to the accuracy of scientific findings, which means the extent to which the conclusions are reliable and correspond to reality. Me & MyCity as a teaching method was studied through two observation units: teachers, and pupils. The material was collected through a thematic interview and studied with a ground-based research approach from the Straussian trend. It allowed the import of ready-made categories into the research process. The research material has been collected in natural situations, in a natural context in schools. Additional material was collected immediately after visiting Me & MyCity in Pirkanmaa. That's how it best verifies reality.

The internal validity of the study is considered in relation to the study results. Internal validity can be improved by interviewing enough and for a sufficient period. This provides enough information about the phenomenon under study. The review is based on students' experiences of Me & MyCity (Kolb, 1984.). Additional material was collected from pupils immediately after their visit to Me & MyCity (2019). Another additional material, TAT Analytics (n.d. Report) <https://tat-ry.bibook.com/analytics/report/f215138e-0e19-41ad->

8c30-25261e4c36b2 (2024) was used to confirm the research results like an earlier article from the same source. (See: Ojala, 2021.).

The problem of conceptual validity can be reduced by the researcher's prior knowledge of the context. (Strauss & Corbin, 1994, p. 280; Karila, 1997, p. 155) emphasize good knowledge of the research subject. There are few studies in the area (Kalmi, 2016.) Instead, the researcher has more than 30 years of experience as a subject teacher. It is likely to increase the reliability of the research subject. External validity describe-show research describes reality. If key concepts cannot be derived from the theory, the conceptual validity of the research is poor (Hirsijärvi, & Hurme, 2001, p. 129; Hirsijärvi, 2007.). These core categories of research are Me & MyCity as a Teaching Method and Pupils' Experiences of Me & MyCity. The theory of Me & MyCity helps to structure, develop, and bring an addition to Me & MyCity teaching method in a certain area of substance. (See: Yin, 1989.) However, it should be noted that Me & MyCity learning environment is based on Finnish national curricula. This must be considered when considering the generalizability of Me & MyCity learning environment. A further research, I suggest more visit (for example twice in academic year) to Me & MyCity learning environment and clarifying the teaching materials to make them suitable for students. This way learning will deepen (Kolb, 1984).

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Chapter # 9

A FRAMEWORK FOR EARLY DETECTION OF WEAK SIGNALS OF STEM-RELATED APTITUDES

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ABSTRACT

The present work aims to establish a research framework and an appropriate procedure for the assessment and identification of emerging skills related to STEM (as weak signals) from primary school so that students have the necessary training and support to adapt to universities and future workplaces. As methodology, the study is based on directly observed and/or personal experienced cases in the Romanian engineering higher education as well as pre-university education cycles, which are complemented by pilot tests designed for this purpose. Secondary research (literature survey) marks the literature gap and complement the matter under investigation. Since this is a pioneering effort, several challenges are foreseen. This project can be risky in the long term because positive/negative outcomes can occur, requiring a step-by-step approach. Nevertheless, the lessons learnt, and implications are important for the main stakeholders: education policy makers and administrators, students and professors alike (Grigorescu & Scarlat, 2025).

Keywords: technical higher education, engineering skills, STEM (science, technology, engineering, mathematics) competencies, STEM-related aptitudes, early detection of weak signals.

1. INTRODUCTION

In the second half of the 19th century, in psychophysics, the theory of signal detection appeared. A century later, it came back to life when it was discovered that the sensations generated by neural noise do not fall below the threshold of awareness. More adequately called the theory of “weak signals” detection, the philosophy and model of this theory was conceptualized by both Gaussian and non-Gaussian models. It proved to be useful when earlier the signals are detected, then better. The applications have extended time spectre – from avoiding a negative phenomenon with rapid evolution (in medicine or catastrophic earthquakes) to predicting future evolution of a certain system, in a large range of areas: from electronics to strategic management (strategic early warning system) and economics (agriculture or market prediction). The decision can also vary according to time, the area of application, starting from fractions of seconds or minutes in case of catastrophic events, or weeks or months in the field of agriculture.

While the extant literature is rich in many areas (psychophysics, neuroscience, psychology, medicine, electronics and telecommunications, geophysics or economy), the literature related to applications of weak signals theory in education (engineering studies in particular) is almost non-existent. Engineering skills – part of STEM (Science, Technology, Engineering, Mathematics) competencies – are trained during costly engineering studies. However, cases of engineers less talented or unhappy with their engineering jobs are sometimes met. The authors had the opportunity to meet young people with non-engineering

studies, but who occupy jobs with technical profiles. In these situations, family influence and career guidance achieved during school are the main reasons for the discrepancy between the young people's studies and the chosen workplace.

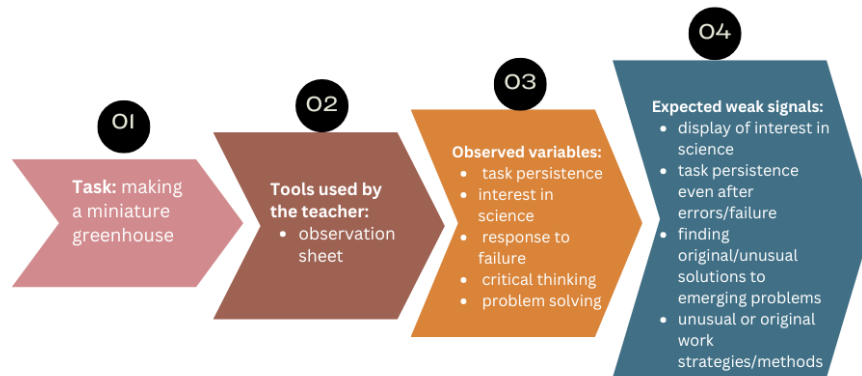
Weak signals in the STEM context are, in fact, micro-cues found in psychometric or behavioral data. A combination of existing instruments would be far more useful in identifying weak signals than a single test, because early detection requires integrating cognitive, affective, and behavioral variables (Ahlqvist & Uotila, 2020).

STEM weak signals can be cognitive, behavioral, affective, or a combination of these, and they can be measured through various psychometric tests. For example, unusual or original problem-solving strategies may constitute weak cognitive-behavioral signals (Hencke et al., 2022). Providing original responses to scientific or technical tasks, or combining concepts in unusual ways, can also constitute weak signals in the STEM field (Almeida et al., 2008).

With regard to affective weak signals, these consist of students' sustained interest in experimental activities or empirical research, demonstrating intrinsic motivation for learning science (Shawn et al., 2011). In addition, the reformulation of strategies and persistence in tasks even after encountering errors may represent a weak signal (Zimmerman, 2007), as can atypically accelerated trajectories in specific domains (Allensworth, 2013).

Figure 1 presents an example of a task that could lead to the identification of certain STEM weak signals. The use of such activities to identify STEM weak signals could help support the development of STEM-talented students and prepare them to obtain jobs for which they are well equipped, thereby improving the quality of education. Moreover, equipping STEM-talented students with domain-specific competencies helps them be better prepared for the labor market in general, providing skills that enable them to cope with the multiple challenges of an ever-changing society.

Figure 1.
Example process for identifying weak STEM signals.



Source: Authors

The present study aims to develop a suitable research framework and methodology for the early identification and assessment of emerging STEM-related skills (seen as weak signals) during pre-university education cycles, with the aim of facilitating better correlation between students, their future engineering education and subsequently their engineering careers.

2. LITERATURE SURVEY

Many studies on the perception of weak signals began in 1970 in the field of strategic planning. In recent years, research has also emerged in other fields, using different terms, which has led to various descriptions of weak signals (Van Veen & Ortt, 2021).

Early warning systems initially emerged within military and security frameworks to identify threats to national security. Currently, the concept of early warning has been successfully applied in the context of maintaining stability in the international security environment (UN, NATO, etc.), natural disaster forecasting, epidemic control, as well as in project and business management. The advantages of using such a system include identifying and learning lessons, proactively recognizing opportunities and threats, scenario analysis, and laying the groundwork for strategic business simulations (Popescu & Scarlat, 2015).

Weak signals employed in the process of identifying unforeseen events, such as diseases, come from the realization that these may be warning signs of accidents or other crises, identified only in retrospect. Frequently, weak signals are ignored if they go against general expectations about the future or if they are unusual, or if they don't agree with traditional ways of privity to things (Liff, Eriksson, & Wikström, 2017).

Often, weak signals are emerging phenomena that are the first signals of a major change that is about to happen. Observing weak signals can identify the seeds of change and classify them. The "standard" theoretical base is represented by the Ansoffian perspective. This requires the weak signal watcher to identify linearly progressing problems in their early stages. In formulating the premise of weak signal theory, the "standard" version of this theory assumes an emerging problem perceived in its rudimentary form. Weak signals represent not only the identification of a linear emergence, but also the changing positions and contexts of observers (Ahlqvist & Uotila, 2020).

The theory of weak signals in medicine is successfully used for the early detection of rapid negative phenomena, such as the evolution of diseases. The biggest challenge facing those responsible for improving and regulating patient safety is how to identify, integrate and act on early warnings and weak signals of risk before they contribute to a catastrophic failure of care (Macrae, 2014).

In geophysics the weak signals are also successfully used, specifically in predicting catastrophic earthquakes. The prediction of an earthquake is challenging, with many countries conducting extensive research on this topic. Using the local cross-correlation tracking method can reflect the correlation between electromagnetic data (Xie et al., 2022).

In public education, early skills have become an important issue for teachers, which are essential for them to investigate ways to close the gap in academic achievement to the national level. Pathways to future academic achievement are, in most cases, shaped in the early years, when children learn essential skills that help create a foundation for later development of a set of academic skills and achievement. Many studies emphasize that many children possess certain early abilities, thus having an advantage over their peers in the process of achieving academic performance (Hein, Smerdon, & Sambolt, 2013).

Regarding the development of STEM potential, this includes expanding students' capacity to understand and appreciate certain deep mathematical ideas, concepts, or scientific notions, perseverance in challenging explorations, and the belief that mathematics and science are valuable and that mastering complex concepts requires diligent effort (Adams et al., 2008). Students considered talented are those who demonstrate above-average performance in one or more achievement domains. According to the Talent Development in Achievement Domains (TAD) framework, talent development is conceptualized as dependent on multiple factors, with an emphasis on person-related variables such as abilities,

personality traits, and acquired competencies. These variables, i.e., the predictors of talent development, partially vary depending on the domain. Therefore, abilities, personality traits, and acquired competencies are positively correlated with the development of performance and creative productivity in STEM fields (Preckel et al., 2020).

Moreover, at the international level, several studies support the idea that early talent identification and differentiated interventions can prevent the loss of potential and support the development of adaptive and innovative STEM profiles. For example, Sedeaud et al. conducted an analysis of key elements to consider in talent identification. These are: (1) understanding and illustrating the early influences on performance, (2) implementing individualized performance trajectory models, (3) applying corrective adjustments based on relative age, biological factors, and training, and (4) improving the estimation of potential through a holistic approach that integrates “life pathways” (Sedeaud et al., 2025). Therefore, such talent identification is essential to ensure that students are as well-prepared as possible for the labor market.

Early detection of skills is essential for achieving educational and professional success. In the field of engineering education, identifying STEM (science, technology, engineering, mathematics) skills from pre-university education can have a positive influence on the career guidance process and help students choose careers that suit them and they bring satisfaction and fulfilment. When these early skills identification mechanisms are missing, individuals end up in unsuitable careers, leading to unfulfillment and burnout. This idea is supported by a study conducted within global companies that shows that low-performing employees are from technical fields, but prefer managerial fields, and those who report low levels of professional burnout are those who have a career fit (Biron & Eshed, 2017).

The integration of weak signals theory in the field of education can also be approached through its connection with established educational theories, such as social constructivism (Vygotsky) and Experiential Learning Theory (Kolb). Based on constructivist theories, teachers can observe and subsequently leverage weak signals in students’ behavior, identifying emerging interests or yet unexplored talents. This contributes to the personalization of learning and the development of competencies based on the talents identified.

Furthermore, Experiential Learning Theory posits that people learn through the transformation of experience. Thus, by engaging in diverse experiences, students have the opportunity to reflect on them, formulate principles or lessons, and then apply them in various contexts, thereby repeating the learning cycle and developing specific competencies. Detecting and analyzing weak signals creates a culture of reflection and adaptability, contributing to effective talent management in an educational context and aligning teaching strategies with current and future societal challenges.

Therefore, weak signals not only anticipate future trends but also contribute to continuous adaptation based on flexible benchmarks, while remaining aligned with student-centered educational paradigms and the development of individual potential. It is necessary that teachers and other educational actors are able to detect weak signals of students regarding these abilities for the early detection of abilities. Weak signals are not just simple “weak evidence of future changes” but represent starting hypotheses for a lot of future-oriented knowledge processes. Rossel (2012) mentions that there are a number of research topics that support the idea that weak signals are easy to identify and the constructivist position that places weak signals within a complex system. On the other hand, despite the fact that weak signal detection theory has been successfully applied in fields such as medicine, economics or telecommunications and strategic management, its application in education, and especially in the field of engineering, is still unexplored territory.

A 2016 study provides a detailed analysis of seven core STEM courses, examining how resources were used and their correlation with final grades. Through logistic regression, researchers observed that students who extensively use exam preparation resources have higher chances of achieving good grades, whereas those who rely more on lectures have lower chances (Waddington et al., 2016).

Recent technologies can be used effectively in Early Warning Systems (EWS) to predict students who are suitable to pursue STEM disciplines further, as well as those who are at risk of not succeeding. Therefore, both teachers and students can make informed decisions to provide support and guide towards the best solutions. Leveraging the wealth of data generated on online learning platforms, the use of EWS can predict students with low chances of success before the end of the semester (Yu & Wu, 2021).

As global trends such as Artificial Intelligence (AI) and machine learning are increasingly being integrated into the field of education, the framework proposed in this article aims to improve strategies for personalizing students' educational trajectories, providing them with opportunities to participate in interdisciplinary and experiential activities to develop competencies relevant to the digital labor market.

A recent study on the integration of artificial intelligence in STEM education highlights that such integration contributes to methodological diversity and to the discovery of global perspectives on personalized STEM education enhanced by AI (Sun et al., 2025). Therefore, artificial intelligence can help facilitate the personalized learning process, which is also one of the ultimate objectives of the proposed early identification framework. Through personalized learning, based on the STEM weak signals exhibited by students, they can more easily reach their full potential.

Early Warning Systems could help students remain engaged in the STEM field and ultimately secure employment opportunities within this domain. By identifying struggling students early on, educators can intervene promptly with targeted support strategies tailored to the specific needs of each student. In Chicago, many schools have used early warning indicators to develop strategies for improving student performance and examine patterns in the indicators to strategically address students' low performance based on specific issues observed in the school (Allensworth, 2013).

Integrating students' behavioral signals and entry profiles helps predict their success in STEM courses. Behavioral signals such as the number of correct responses to in-class questions, slide and video views, can serve as stable predictors of students' success throughout the semester. Using behavioral signals and student profiles enables the prediction of student success. Also, early warning systems that leverage diverse student data can aid in developing other innovative predictive features for student success and contribute to designing an enhanced early warning system (Nam & Samson, 2019).

Recent studies strongly recommend using early warning systems to identify at-risk students. A study conducted in 2018 examined eight prediction methods and investigated the optimal timing for implementing such a system within a course. The study's findings indicate that the ideal time for implementing an early warning system is around weeks 5-6 (Howard et al., 2018).

This chapter proposes a novel approach and framework for the early identification and assessment of emerging STEM-related skills as weak signals during pre-university education cycles and it is largely based on preceding studies. Such an approach is necessary because today's society is evolving rapidly and the amazing technological progress puts a lot of pressure on educational experts to provide students with adequate training from the earliest ages, so that the skills they acquire will be useful to them in the future workplace. Teachers must be able to identify, assess and develop the skills of each student, and for this to be

possible they need effective methods and tools to identify weak signals of students. It should also be mentioned that the discrepancy between the educational offer and the needs of the industry highlights the need for universities to offer appropriate study programs to train future engineers, and for the professional requirements of education to be integrated and aligned with the requirements of the labor market (Grigorescu & Scarlat, 2024).

3. METHODOLOGICAL APPROACH

The methodological approach of this study is a mixed one and consists of direct observations and personal experiences of the authors. Observations were conducted at the pre-university level in a private high school in Bucharest, Romania, over the course of an entire school year, with 18 fourth-grade students aged between 9 and 10. The observed activities took place both in formal classroom settings and during extracurricular activities dedicated to integrated STEM initiatives (including programming sessions, problem-solving through simple experiments, and hands-on projects). Observations followed an informal rubric developed by the authors, focusing on elements such as students' initiative in technical activities, duration of attention span, types of strategies used in problem-solving, teamwork, and responses to open-ended tasks. To ensure data consistency, the authors systematically recorded emergent behaviors immediately after each session and triangulated these notes with reflective discussions among the researchers.

Additionally, the authors conducted observations at the university level at a public university in Bucharest, Romania, involving first-, second-, and third-year engineering students. The observed activities took place in classrooms during formal teaching sessions and practical applications. The number of students varied throughout the academic year (between 20 and 60 per group), depending on participation in the courses and seminars delivered by the authors. Data on students were collected through direct observation and spontaneous discussions with participants. Subsequently, the data were categorized according to identified behavioral patterns (e.g., approaches to technical tasks, collaboration style, resilience in facing open-ended problems, initiative in projects) and then analyzed thematically.

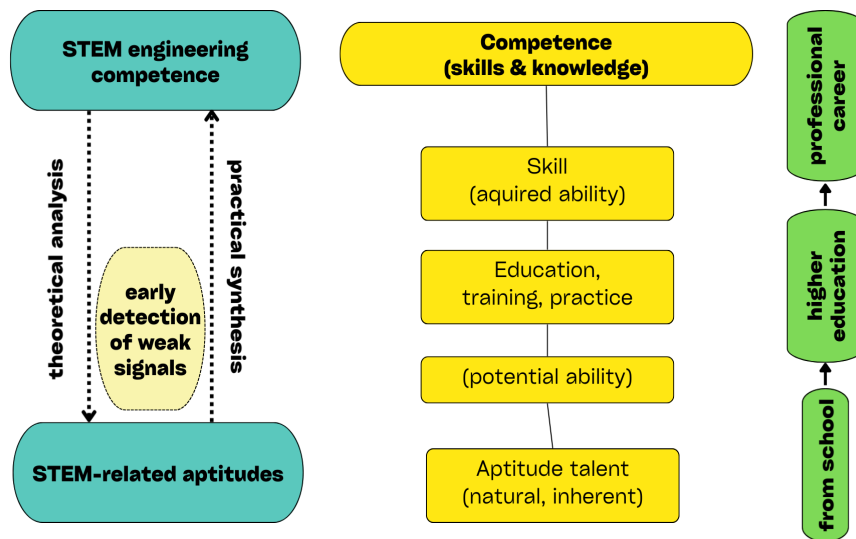
To strengthen interpretations, the authors also sought additional evidence in the data, including concrete examples of recurring behaviors and the frequency of observed patterns. Currently, the study does not include images or quantitative statistics, but such documentation is planned for the next phase of implementing the weak signals identification framework.

Also, the study includes secondary research (specialty literature analysis) that highlights the existing gaps in the profile literature and supports the theoretical framework of the investigation. The adopted methodology is one with an exploratory character, considering the fact that the application of the theory of weak signals in education is too rare, especially in the field of engineering education.

The authors' observations are intended to optimize the orientation of students towards an appropriate engineering education, so that young people are oriented towards a career that suits them according to their potential and interests. This is a pioneering initiative and is only the first step towards a procedure and tools for identifying emerging weak STEM signals. The authors anticipate several challenges, including risks associated with false-positive or false-negative results. Therefore, the methodology proposes a gradual approach, allowing adjustments along the way and learning from accumulated experiences. The implications of this research are relevant to several stakeholders: educational decision-makers, teachers, students and administrators of educational institutions.

This study contributes to developing a suitable research framework and methodology for the early identification and assessment of emerging STEM-related skills (Figure 2), aiming to facilitate *better correlation between students, their future engineering education and their future engineering careers.*

Figure 2.
A scheme of research approach.

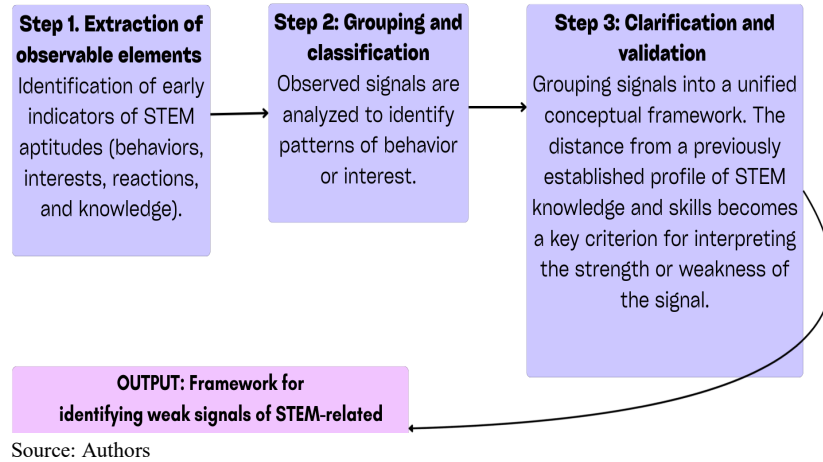


Source: Authors

This article represents an important step in the process of creating a framework for early detection of weak signals of stem-related aptitudes. The methodological framework for detecting weak signals associated with STEM skills was made by adapting the three-step approach proposed by Van Veen & Ortt. The authors of this approach claim that the "weakness" of the signals is defined as the distance from the frame of reference of the perceiver, and the three stages proposed by them are: the perception of the signal, the interpretation of the signal and its implementation (Van Veen & Ortt, 2021).

Starting from the three-step approach of the authors mentioned above, the weak signals detection framework is presented in the figure below. This provides a tool for the early detection of STEM skills by extracting observable indicators (behaviours, interests, reactions, knowledge, etc.) that may signal the emergence of STEM skills. Next, these indicators can be grouped into recurring patterns and different levels of "weakness", and finally these signals can be integrated into a conceptual framework, where the degree of distance from the student's previous knowledge and skills becomes the main criterion to evaluate the strength or weakness of the signal.

Figure 3.
Weak signals detection framework.



The previously proposed framework aligns with the logic of existing early warning systems used to identify students at educational risk but focuses on the early detection of weak signals of STEM potential.

An example of such an early warning system is the Early Warning Mechanism in Education (MATE) in Romania. This is an institutional and procedural framework based on a set of tools designed to identify students at risk of dropping out or leaving school prematurely, with the aim of supporting them to continue and complete their studies, based on early signals recorded in Romania's Integrated Education Information System. The framework relies on real-time data collection regarding early signals (low academic performance, grade repetition, absences, inappropriate school behavior), helping teachers and other decision-makers implement appropriate and immediate measures to mitigate risks and problems identified among students (<https://mate.edu.ro/>).

Similarly, the proposed weak signals detection framework seeks to systematically identify observable indicators (interests, behaviors, reactions, etc.) that could signal the emergence of STEM competencies. This helps teachers plan learning activities in line with the talents identified among students to support the development of specific skills. Thus, early warning systems like MATE transform incipient risk signals into support actions, while the proposed framework transforms STEM weak signals into starting points for counseling, academic guidance, and the design of educational trajectories aligned with future STEM careers.

4. FINDINGS

To identify talented STEM students in primary school, the authors made direct observations of the students' involvement in STEM-related activities. An example of such activity was the design and 3D printing of key chains. The students worked in teams of two, at the computer, where they designed, based on predetermined models and with the help of specialists, personalized key chains. They also had the opportunity to print them using 3D printers. During the activity, there were students who demonstrated critical thinking, good logical and analytical thinking skills, but also spatial and technical thinking.

These children, if they *benefit from an educational process that supports them in developing these skills, have a high chance of achieving a successful career in engineering.* An example of an activity carried out within the primary cycle is that of building a city from recyclable materials. In this activity, students worked in teams, collected the right materials, designed and built a miniature city. They also had the task of building a bridge that would support the weight of a toy car, but also a simple circuit with batteries and light bulbs that would take the place of the street lighting in their city. The activity stretched over several hours, and the students had limited resources at their disposal. Students who managed to find innovative solutions and solved the problems encountered during the project were noted. Through this activity, one can observe students who have the ability to solve problems, who have an increased interest in science and technology, but also spatial and technical thinking. It is an activity that can help teachers identify students' weak signals and develop them in the future.

In pre-university education, preparing students for the labor market and for life in today's constantly changing society is also achieved through various projects and programs implemented at the national level. Two such programs are called "*Green Week*" and "*School Otherwise*". Within these programs, students are given the opportunity to participate in extracurricular activities through which they develop different skills and gain knowledge from various fields. The diversity of activities and of the people students come into contact with helps them discover more about their own talents, making even weak signals of STEM aptitudes more visible. Teachers play a key role in observing these weak signals in time in order to encourage and help students work on identifying and strengthening their abilities.

An example of an activity where students can discover their STEM skills is related to robot programming. Students take part in workshops where they learn how to build a robot from scratch and program it to perform simple tasks. These activities take place in several stages, giving those who show interest and passion for this field the opportunity to advance and carry out increasingly complex activities. Another important aspect is the opportunity to participate in various competitions with the robots they have built.

Another example is represented by activities carried out by parents within these programs. Parents are invited to class to present their profession and engage in different activities with students. They can also organize activities at their workplace. VanMeter-Adams et al. argue that students gain their interest in STEM from extracurricular experiences as well as childhood events, while hands-on lab activities sustain this interest. The same authors highlight that community-based programs involving both children and their families are essential in sparking and maintaining long-term interest in STEM (VanMeter-Adams et al., 2014). One such activity in which students had the opportunity to learn more about STEM and test their abilities was a visit to a power station. During the visit, students observed how the station functions, used certain equipment under staff guidance, completed tasks using VR (virtual reality) tools, and worked in teams to solve specific challenges. During these activities, teachers were able to observe passionate students and those showing weak signals of STEM aptitude.

Another type of extracurricular activity where students can express potential weak signals related to STEM is the *Science Fair*. In this event, students present their projects and compete for prizes that may include experiences (e.g., visits to museums, institutions, workshops) or material rewards (toys, laptops, school supplies, etc.). Students prepare for the fair months in advance and are guided by teachers throughout their preparation. They can also seek help from parents or specialists from various fields, but the actual work is their own. Participation is based on registration, and students can register individually or in teams. To validate their registration, they must present the project plan and the stages they will

follow to complete it. Examples of such projects include: a bicycle that generates electricity, smart water filtration systems, recycling systems, a smart nightstand, robots for the visually impaired, and other projects aimed at improving people's lives and reducing pollution.

Therefore, extracurricular activities within nationally implemented programs (and beyond) can help teachers identify students' weak signals, making it easier to recognize those with a natural inclination toward STEM. Once such students are identified, teachers can support them in improving their skills, provide activities that nurture their curiosity, and offer guidance regarding their future.

As far as hands-on STEM experiments, making a volcano using baking soda and vinegar is one of the activities that get students engaged and engaged. This type of experiment gets students interested in science and technology, but also tests their collaboration, teamwork, or logical thinking skills. In the university environment, game-based activities involving STEM simulations, such as programming robots or solving virtual challenges through educational software, are effective methods of testing students on their STEM talents and abilities. During these activities teachers can gather valuable data about students' talents and how they can help them develop further. Another type of test is one that is based on logical rip-puzzle activities or reasoning problems that aim to assess students' critical and analytical thinking. These activities give teachers the freedom to customize them according to the theme of the course, while also testing the students' skills/weaknesses in the STEM field.

These tests and experiments, based on a representative sample, should provide a clearer picture of the process of identifying weak signals among pupils and students, the results being useful in drafting recommendations for teachers and educational counselors regarding the career guidance of students.

Figure 2 shows the route taken by the students, starting from primary school and ending with a professional career. The authors propose this route model that could be followed in order to identify weak signals of students early, based on the progressive development of their skills. First, it emphasizes the native aptitudes of individuals, that is, those innate traits that reflect natural talent and inclinations. The second step is the analysis from the perspective of the student's potential, evaluating his latent ability to learn and progress in certain areas. Next, the emphasis is on acquired skills, developed through education and practice, thus consolidating what the student has already learned and is able to apply in practice. The end of the path is completed by the achievement of competence, which sums up the skills, knowledge and attitudes necessary to perform successfully. The proposed model provides a clear framework for understanding and supporting student progress from potential to performance, i.e., from low signals to achievement.

In terms of activities observed in the university environment that can help teachers identify weak signals of students, an example of an activity is represented by problems that put students in difficulty and test their ability to solve problems, think logically and criticism, but also teamwork. One such problem is related to finding an optimal solution for street lighting in their city. The students worked in teams and had access to resources such as course materials and the internet, creating a sustainable street lighting project. In this way, students who have problem-solving, collaboration, teamwork, problem-solving, and spatial and technical thinking skills were noticed.

Participation in conferences and workshops is encouraged. Students are supported to participate in such activities by presenting scientific papers or participating in debates on current technological topics. In this way, students are motivated and can discover or develop their STEM talents or skills. Such informal activities are extremely beneficial for students and add value to the instructional-educational process. It is also in such situations that teachers can identify students who show talent in the STEM field and help them develop further to reach their full potential.

5. LIMITATIONS AND FURTHER STEPS

The present research has several limitations; the first one being related to the lack of longitudinal data. In addition, the lack of concrete data on the application of the tests among pupils and students is another major limitation. In addition, false positive or false negative results should be considered in terms of the application of weak signal theory in education. The authors propose the continuation of the process of carrying out a procedure to evaluate and identify emerging skills related to STEM (as weak signals) during pre-university education cycles. The previously presented pilot tests are to be applied among pupils and students, and then the results of the participants will be analysed for validation. The authors also propose the development of tools to be applied in pre-university education with the aim of identifying weak signals related to STEM, thus contributing to increased chances that young people who choose to study STEM disciplines in university to have higher chances to be successful while pursuing an engineering career (Grigorescu & Scarlat, 2025).

6. CONCLUSIONS

In the field of education, the theory of weak signals could be successfully applied by teachers, thus helping students to develop their natural talents and thereby form skills and then competencies that will help them in their future careers. The implementation of an early warning system would help in the career guidance process; thus young people would no longer end up occupying positions or different fields that do not suit them. Since we live in a society that requires talented STEM workers capable of facing challenges, teachers and other decision-makers should place greater emphasis on systematically observing STEM activities in the classroom, identifying and nurturing weak signals in order to provide differentiated tasks, collaborating with parents and the community to offer students diverse experiences that motivate and spark their interest, and promoting project-based and experiential learning. This creates opportunities for students to develop not only STEM competencies but also skills that help them thrive in an ever-changing society.

Thus, the methodology used—based on direct observations, educational experiences, and the analysis of specialized literature—supports the idea that weak signals theory can be successfully applied in education. Moreover, the application of the model proposed by Van Veen & Ort (2021), structured around perception, interpretation, and implementation, provided a useful framework for the early identification of STEM weak signals among students. Through practical STEM activities, contexts can be created for identifying early signals of STEM aptitudes, and teachers' observations during these activities, correlated with skills such as critical thinking and creativity, illustrate the presence of weak signals.

The research therefore emphasizes the importance of early identification of STEM skills among pupils and students, considering their impact on educational and professional success. The application of the theory of weak signals in the field of education, especially in engineering education, can positively contribute to the process of adequately orienting students towards careers in the technical field, highlighting the students' potential. The studies presented and the observations made by the helpers contribute to a better understanding of this complex process of identifying weak signals and using them for the benefit of students. Early identification of STEM talents can support students in choosing an appropriate educational and professional path, thus eliminating unfulfillment and burnout. Implementing early warning systems and using practical tests and experiments can help teachers use valuable tools to support the development of these skills. However, as a relatively new approach to education, the application of weak signal theory requires a flexible

and adaptable framework that can be adjusted as more experiences and data accumulate (Grigorescu & Scarlat, 2025).

The declared purpose of this chapter is to exemplify how the talents and aspirations of young people for a certain career can be detected as early weak signals (in this case the engineering career), but the "early detection of weak signals" approach can be used, *mutatis mutandis*, in the case of any other career. One of the important reasons that led us to choose engineering studies for this essay is the significant dropout rate in this field (Grigorescu, Scarlat & Simion, 2025).

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Chapter # 10

SCIENCE COMMUNICATION AS A FIELD OF PRAXIS: A theoretical model of converging domains

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ABSTRACT

Science Communication (SC) has expanded across multiple formats and platforms, but it lacks a theoretical consensus on its nature and purposes. This chapter proposes a theoretical model that understands SC not as a process or an instrument, but as an autonomous field of praxis. The model argues that SC materialises its practice at the convergence of four fields—the scientific, the communicational, the educational, and the technological—and operates through a process of negotiated autonomy. This praxis-based approach opposes traditional paradigms of discursive reformulation and genre, which reduce it to a merely instrumental view. Instead, we consider SC as an intentional and reflective action that redefines itself, its object, and its purpose. The model suggests that SC must present science in action, aim to expand the public's conceptual profile, and foster a relationship of mutual enrichment between science and society. This approach seeks to strengthen trust in science, recognising it as a pillar of a more just and democratic society. The model also offers conceptual guidance for the design, analysis, and evaluation of communication practices across diverse institutional and social contexts.

Keywords: science communication, field theory, otherness, conceptual profile.

1. INTRODUCTION

Science Communication (SC) occupies an increasingly prominent space in contemporary society. Driven by both new information and communication technologies, as well as social demand, its production expands into multiple formats and platforms. Paradoxically, this practical expansion contrasts with a persistent lack of theoretical consensus on its fundamental nature (Lima & Giordan, 2021). Faced with this scenario, this chapter aims to propose a theoretical model that understands SC not as a process, discourse, or tool, but as an autonomous field of praxis interconnected with other fields. Our proposal aligns with an emerging sociopolitical turn in Science Education (Moura, 2021), contributing to the field of SC toward values of social justice and collective well-being.

Historically, attempts to define SC have been dominated by two main interpretations. The first, and most traditional, conceives of it as a discursive reformulation—a kind of translation or simplification of a specialised source discourse, such as the scientific one, into a language familiar to the public. More recently, a second perspective proposes SC as its own distinct discursive genre, characterised by relatively stable thematic, stylistic, and compositional features. Despite both definitions being relevant, we consider that these views are insufficient, as they limit SC to a communicational or discursive perspective that neglects its practical complexity (Lima & Giordan, 2021).

The proposal defended here is that SC should be understood as an autonomous field (Bourdieu, 1989, 2004) that materialises its praxis at the intersection of multiple spheres of human activity (Bakhtin, 2011). According to this idea, SC is formed in the dialogue and tension between the scientific, communicational, educational (Grillo, 2006b; Lima & Giordan, 2021), and technological spheres. All these spheres exist and operate under the influence of a larger context, the social, political, and economic instance. In turn, the internal and external dynamics of these fields are animated by the active participation of the public.

Advancing this definition requires rethinking its objectives. We propose articulating the purpose of SC praxis in relation to the Conceptual Profile model (Mortimer, 1996). We argue that SC should aim to expand the public's scientific capital (Archer, Dawson, DeWitt, Seakins, & Wong, 2015). This model seeks to reinforce the relationship between science and society by embracing the genuine nature of science (Marras, 2016).

This chapter adopts a theoretical-analytical approach grounded in critical literature review and conceptual synthesis. The proposed model was developed through the systematic articulation of contributions from Science Communication, Science Education, Sociology of Science, and Science and Technology Studies (STS). The selection of references followed three criteria: (i) theoretical works that explicitly problematise deficit, transmission, or instrumental models of SC; (ii) authors who conceptualise science, communication, or education as socially situated practices; and (iii) contemporary contributions that address public trust, scientific culture, and sociopolitical dimensions of science. Rather than aiming at an exhaustive review, the chapter seeks to construct an interpretative synthesis that critically contrasts historical paradigms and integrates convergent theoretical insights into a coherent model of SC as a field of praxis.

2. SC AS DISCOURSE: FROM DISCURSIVE REFORMULATION TO DISCURSIVE GENRE

To advance this discussion, it is essential first to examine the interpretations that have historically underpinned the field.

2.1. Discursive Reformulation

One of the most widespread interpretations understands SC as a linear process of discursive reformulation. In this model, SC is essentially seen as an activity of translation or recodification (Lima & Giordan, 2021), in which a specialised language, hermetic and restricted to peers (Chassot, 2003), is translated into a non-specialised language accessible to a broader audience. The science communicator thus assumes the role of a mediator-translator (Marras, 2016), transposing the source discourse of science into a language familiar to the public. Historically, this perspective has rendered SC a synonym for the simplification of knowledge produced by specific fields, but directed at the masses, comprising supposedly ignorant individuals (Lewenstein, 2003).

The first weakness of the model is its formal infeasibility. The discourse of SC rarely maintains the form or compositional structure of scientific discourse. For example, in science journalism, one of the most recognised modalities of SC (Bueno, 2010), the structure of a scientific article is often inverted. The focus is on applications and results, aiming to capture the reader's interest (Grillo & Olímpio, 2006). Additionally, SC discourse systematically employs resources such as metaphors, analogies and stylistic tools, which are used more restrictively in standard scientific discourses (Lima & Giordan, 2021).

Second, there is the incompatibility of principles between the languages to be translated. Scientific language strives to be univocal, meaning it seeks to establish a systematic terminology in which each concept has a single, precise meaning within its theoretical framework, thereby avoiding ambiguity. In contrast, everyday language is polysemic and contextual by nature. Its words carry multiple meanings, connotations, and an inherent vagueness that, while functional for social life, does not withstand rigorous logical analysis (Lima & Giordan, 2021). The translation between these two symbolic universes cannot be a process of simple term substitution, but necessarily implies a complex recreation of meanings.

Finally, the most forceful critique lies in the ontological and epistemological rupture between science and SC: their objects of reference are not the same. While science has the purpose of understanding the Universe in its concrete conditions, SC should have scientific culture itself as its object. Therefore, SC discourse is not systemic, but referential and contextual (Lima & Giordan, 2021). It only points to a concept or result, without requiring the reconstruction of the entire scientific theory that supports it.

2.2. The Discursive Genre

In response to the translation paradigm, an interpretation emerged that sought to grant greater autonomy to SC, proposing it as a distinct discursive genre. This perspective argues that SC fits the definition of genre as a relatively stable type of utterance, characterised by three elements: thematic content, compositional construction, and verbal style. According to this view, SC would meet these requirements: its theme would be science and technology; its composition would be based on specific structures, such as information segmentation; and its style dispenses with the esoteric language of science by employing analogies, generalisations, and simplifications (Zamboni, 2001). Although this approach represents an advance by moving SC away from the condition of a byproduct of scientific discourse, it also has limitations.

The first limitation lies in the diversity of formats through which SC materialises, such as documentaries or museum exhibitions. Therefore, SC is not a particular genre, but rather an activity that takes place within various genres (Grillo, 2006a), and each of them has its own rules, stylistic, and compositional constraints. Framing such a vast range of practices as a single and stable discursive genre is therefore problematic. The second limitation, which deepens the first, is the influence of multiple fields on the constitution of SC. SC is an activity that transits and suffers coercion from different fields, such as the scientific and the communicational (Grillo, 2006b; Lima & Giordan, 2021), being, therefore, a fundamentally hybrid product molded by the forces and logics of the fields with which it interacts.

3. SC AS FIELD AND PRAXIS

The critical analysis of the translation and discursive genre understandings reveals their insufficiencies in accounting for the complexity of SC. To overcome these views, we support the understanding of SC as praxis, as proposed by Lima & Giordan (2021). This change shifts SC to an intentional, conscious, reflective, and transformative social action. Under this definition, SC must have clear objectives and seek to transform society's relationship with science. This statement prompts communicators to reflect on their practices, the impact of their messages, and the public's needs.

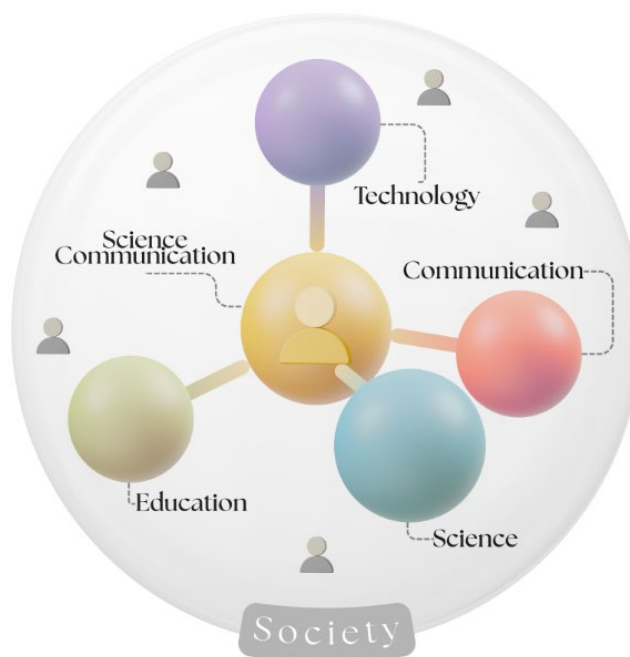
This praxis emerges at the complex intersection of multiple spheres that have specific internal dynamics and discursive practices (Bakhtin, 2011). In this sense, it is necessary to ground SC as an autonomous field, a social space of struggle (Bourdieu, 1989, 2004).

The SC can be understood as an autonomous field that produces discursive genres with specific purposes as they approach their spheres of intersection. That is, SC has its own rules and professional identities, appropriating and integrating the logics and capital of adjacent fields. It is thus constituted in the dialogue and tension between the scientific, communicational, and educational spheres (Grillo, 2006b), as well as the technological sphere.

4. THE FOUR SPHERES THAT DEFINE THE SC AS A FIELD

The autonomous and interconnected nature of SC can be visualised as a central sphere surrounded by four spheres (Figure 1), creating a five spheres model. Each of these spheres is a field of action with its own logic and capitals (Archer et al., 2015; Bakhtin, 2011), including the central sphere, which is the SC. It is essential to understand that this structure is not isolated; on the contrary, it is immersed in a larger system—the social, political, and economic context—that sustains and influences the entire structure. Funding interests, public science and technology policies, social agendas, and dominant ideologies shape what is considered science worthy of being communicated and how it should be expressed. Thus, the model reveals SC as a field that, although autonomous, is deeply anchored in its historical, cultural, and political context.

Figure 1.
The Five Spheres Model of Science Communication (SC).



The autonomy of SC signifies that SC is not a passive conduit for other domains. Instead, it utilises specific knowledge from each of its intersecting spheres, transforming it to characterise its own internal rules, validation mechanisms, and forms of symbolic value,

which the actors within it uphold. Furthermore, no field possesses absolute autonomy—not science itself, nor politics, nor the media, nor education. The strength and resilience of the SC field, therefore, lie not in achieving isolation but in its constant capacity to negotiate its autonomy with these intersecting domains. Because of this, SC avoids being merely subservient or instrumental to other fields. Viewing SC through this lens, we are compelled to examine the broader conditions of its production, circulation, and reception.

4.1. The Scientific Sphere

The scientific sphere, in this model, provides SC with epistemic capital, that is, the content, establishing a relationship of mutual importance. It is necessary to consider that this sphere, far from being merely a body of knowledge and a homogeneous block, is a field of disputes traversed by distinct interests and worldviews (Moura, 2021). Science itself has been driven by the imperatives of competition and productivity, going against the grain of slower and more reflective scientific practices that are attentive to their consequences (Stengers, 2023). Therefore, SC should not dialogue with “The Science” as a single entity, but positions itself in the midst of this plurality of practices, choosing which voices and which models of science it will bring to the public arena.

Given this, what science should be presented? One of the biggest mistakes of traditional SC is to focus exclusively on the results, consensuses, and cold certainties of science. An alternative is the presentation of science as a cultural process “entangled in its mediations and controversial conditions, full of uncertainties and fragilities” (Marras, 2016, p. 99). This proposal highlights science in action (Latour, 2012) that breaks down the walls of the “sacred enclosures” (Marras, 2016) and exposes the true nature of science.

At this point, a pertinent objection can be raised: wouldn't we be providing ammunition to its detractors by exposing the hesitations of science? The answer lies in the understanding of the constitution of trust. The historical insistence on operating under the motto of science, which seeks to prove facts, may have produced an unexpected rebound effect in the digital age. By presenting itself as a distant and infallible authority, it may have fostered an estrangement and repulsion from a public that did not participate in its construction process. Furthermore, the first sign of revision can unsettle the conception of science as absolute truth. This scenario leaves a space readily filled by denialist movements—which, ironically, mimic this same language of authority to gain prestige (Germano, 2011).

Trust in science should not be justified by a single infallible method or by the genius of individuals, but by its character of critical scrutiny. Knowledge becomes trustworthy when it withstands the evaluation of a diverse community of experts, generating a consensus (Oreskes, 2019). Its strength lies not in a central dogma, but in its distributed self-correction mechanism: peer debate, replication of experiments, revision of theories, and so on (Harari, 2024).

By opening the sacred enclosures to expose the controversies, science is not showing weakness; on the other side, it can demonstrate that a network designed to self-correct is different from an echo chamber, which, like denialism, is intended to self-affirm. This opening of the process is a political act. A society that understands that science progresses through doubt and debate will be better equipped to identify the false certainties of anti-scientific discourse.

Furthermore, the refusal to disclose the process not only fuels mistrust but also creates conditions for the fallacy funnel—the mechanism by which rational people are drawn to irrational beliefs (Ariely, 2024). This funnel can begin with a seed of doubt regarding an authority or scientific knowledge, which traditional SC can plant. Instead of offering a decree, the proposal to show science in action provides an invitation to understand the scientific process. By making the reasoning transparent and showing the debate, SC occupies a space that misinformation would fill.

4.2. The Communicational Sphere

SC is associated with the communicational sphere beyond its vehicles and strategies for communication. The focus here is not only on the media aspects, but on the very nature of the communicative act: the dialogue, the negotiation of meanings, and the recognition of the other as an interlocutor. This sphere provides SC with the logic and tools necessary to perform its role. This dynamic moves away from the transmission paradigm. It delves into the praxis of dialogue, where the message is built not on a one-way street, but in the continuous interaction between the speaker and the listener. The success of SC, therefore, depends on the ability of its agents to operate within a two-way logic, using communication tools to establish a relationship of otherness with the public.

4.2.1. The Role of the Public: From Passivity to Otherness

This model repositions the role of the public, abandoning its conception as an indistinct multitude or passive recipients (Marras, 2016). The public has its own active cultural repertoire, a set of knowledge and values that mediates the way any message is received, understood, and resignified. An individual's Scientific Capital (Archer et al., 2015) is unequally distributed socially, which explains why specific publics feel more or less at ease with science. It is not due to a simple lack of scientific knowledge, but rather to a complex web of life experiences, practices, and social relationships.

Communication with the public is not a benevolent concession of science, but an intrinsic need for its own constitution as a social practice. It is through encounters with others that science can reflect on itself and build meaning. The mechanism for this relationship occurs in a process of otherness. The science communicator needs to put themselves in the public's place to, upon returning to their own, obtain a broader perspective that allows them to understand their own field in a new way (Fetter, 2023).

This dynamic transforms communication from a unilateral transmission into a relationship of mutual enrichment. One might argue why the scientific community should care about this enrichment. The justification unfolds in three essential dimensions, presented below, which update traditional arguments for the contemporary scenario and introduce a new perspective.

In societies where research is extensively funded with public resources, accountability is a non-negotiable ethical duty. Access to knowledge produced collectively is a citizen's right and a prerogative of democracy (Fetter, 2023). Additionally, there is a growing disinterest among young people in pursuing academic sciences (Marras, 2016). Dialogue with the public is essential to inspire future generations, ensure social legitimacy, and provide continuous support for scientific activity in a world with multiple competing sources of information.

The relationship of otherness with the public forces science to leave its sacred enclosures and gives SC greater recognition. When confronted with the questions, concerns, and logics of the non-specialist world, the scientist is compelled to reflect on the assumptions, limits, and ethical implications of their work. This dialogue can generate new research questions and promote a renewal of the sciences themselves (Marras, 2016). Interaction, therefore, is a mechanism of refinement for scientific practice (Fetter, 2023).

4.3. The Educational Sphere

If the relationship with the public is one of otherness, then what should be the purpose of this dialogue? We propose that SC offers a scientific perspective as a new lens for reality, without nullifying other forms of knowledge, thereby increasing the complexity and versatility of individuals' cognitive and cultural repertoires.

4.3.1. The Conceptual Profile as the Objective of SC

Traditional SC models tend to view the public as a “lay”, that is, a homogeneous mass of people who lack scientific knowledge (and need it) or have a distorted and inadequate knowledge that needs to be restored. These views ignore the public’s knowledge and, consequently, how the scientific knowledge communicated will be understood and make sense to them. These conceptions can be associated with a Banking Education (Freire, 2013; Germano, 2011) or a conceptual change (Mortimer, 1996) regarding Science Education (SE). If SE itself, which aims to teach science to the public, has solidly criticised these ideas and given up on them, then why should SC still take them as its objective?

Based on the Conceptual Profile (CP) model (Mortimer, 1996), we argue here that SC should aim to offer its audience opportunities to expand their repertoire. The CP model suggests that learning does not occur by eliminating prior ideas, but by the evolution of a profile of conceptions. It means that the scientific ideas (coming from SE or SC) coexist with the previous conceptions, originating from common sense, with each of them being activated in the context that is most appropriate for it.

In this way, the purpose of SC should not be to supplant the public's everyday, cultural, or traditional knowledge, but rather to provide an opportunity for enriching their CP. The praxis of SC, therefore, must favour the scientific perspective as a new zone in this profile, which begins to coexist with other forms of knowledge, increasing the complexity and versatility of individuals' cognitive and cultural repertoire. The implications of this paradigm shift are highlighted.

First, this model is based on respect and empowerment of the public. By not treating the pre-existing repertoire as an error to be corrected, it recognises the public as an active interlocutor and holder of valid knowledge in their own contexts. Second, this approach promotes a genuine democratisation of knowledge. The idea of filling the public with scientific knowledge, which is the expression of the deficit model’s philosophy (Lewenstein, 2003), by seeking to impose the scientific view as the only correct one, operates under a logic of epistemic imperialism (Latour, 2019; Marras, 2016). In contrast, the CP model offers the scientific perspective as an addition, not an imposition. It thus contributes to an ecology of knowledge (Santos, Meneses, & Nunes, 2006), recognising the possibility of a multiplicity of cultural natures and valuing intellectual pluralism instead of seeking uniformity.

At this point, a pragmatic question arises: can a specific SC action catalyse the development of an individual's CP? So, we believe that the answer is yes. A successful SC action does not exhaust a scientific theory. But it can introduce a new dimension to the profile, generate awareness about the profile itself, and evoke interest in science (Marras, 2016). For many, a single SC action can be the first contact with a scientific approach to a particular subject, laying the groundwork for future learning. A single SC action can spark the curiosity that leads the individual to seek more information on their own, thereby continuing the development of the profile.

From a practical perspective, this can be illustrated by considering, for example, a public communication initiative on climate change. An SC activity grounded in the CP model would not aim to replace everyday explanations - such as seasonal weather perceptions or local experiential knowledge - but to introduce scientific perspectives (e.g., probabilistic climate models, long-term data trends) as additional interpretative zones. These perspectives may later be activated by individuals when engaging in public debates, interpreting news, or making civic decisions, without requiring the abandonment of other forms of knowledge. In this sense, the role of SC is not instructional mastery, but epistemic expansion.

4.4. The Technological Sphere

The fourth sphere, essential in the contemporary scenario, is the technological one, which is not just a channel, but a field with its own logic and capital. The logic of this sphere is driven by factors such as algorithms, engagement metrics, virality, and monetisation. SC, as an autonomous field, needs to appropriate these platforms and tools, subverting their intended purposes.

The influence of this sphere is transversal and extends beyond digital formats. For example, museum exhibitions permeate this sphere in the dissemination of events on social networks, ticket sales, the use of augmented reality, or interactivity. Technology is also essential for collecting engagement data and audience analysis, favouring a reflective and evidence-oriented praxis.

As an illustrative case, digital platforms can be used not merely to disseminate scientific results, but to expose elements of scientific process, uncertainty, and debate. Formats such as short explanatory videos, interactive visualisations, or comment-mediated discussions allow science communicators to foreground controversy, methodological limits, and revision processes. When strategically appropriated, these tools can counter algorithmic simplification by fostering reflective engagement rather than passive consumption.

Instead of submitting to the logic of click and profit, SC must act in these channels to promote the transparency of science and invite the public to understand the scientific process, instead of just accepting its results. This approach fosters a more resilient trust and facilitates a sense of otherness with the public. Therefore, the technological sphere operates as a system that offers, at the same time, an unprecedented reach infrastructure for SC and imposes coercions that the science communicator needs to manage.

4.5. The Construction of Professional Identities

The understanding of SC as an autonomous field interconnecting the four spheres also requires an analysis of the agents that constitute it. Science communicators are professionals with a distinct identity, shaped by their trajectory, capital, and the position they hold in the field. They should develop competencies related to the four spheres, and their identity is, therefore, hybrid.

To effectively perform SC actions, science communicators must possess a strong understanding of scientific methodologies and knowledge, yet rigid academic formalities should not constrain them; use communication strategies without submitting to the logic of immediacy and unilateral communication; master pedagogical and didactic strategies without being limited to the coercions of formal education, seeking to broaden the CP of the public; and understand the architecture of the technological sphere without being hostage to its platforms.

The struggle for capital in the field of SC manifests, for example, in the search for recognition of its practice as a legitimate expertise, rather than just a hobby for scientists or a subgenre of journalism. Far from being translators who limit themselves to presenting undeniable scientific results disconnected from the realities of the public, the success of the communicator's action lies in showing science in action (Latour, 2012).

5. FINAL CONSIDERATIONS

Throughout this chapter, we sought to deconstruct traditional views of Science Communication (SC) and, in their place, systematise a theoretical approach that understands SC in its complexity and autonomy. SC should be conceived not as a translation process or a unified discursive genre, but as an autonomous field of praxis. This praxis materialises at the

intersection of four spheres—the scientific, the communicational, the educational, and the technological—appropriating their logics and capitals without, however, submitting to any of them.

From the scientific sphere, SC inherits the object of its work—scientific culture itself, with its processes and uncertainties—and the need for rigour and legitimacy. From the communicational sphere, it appropriates the channels, the strategies and discursive genres, subverting the logic of mere transmission to establish a genuine dialogue with the public. From the educational sphere, SC extracts the purpose of acting to expand conceptual profiles, offering a different lens to see the world. Finally, the technological sphere provides the infrastructure and digital logic that SC uses to amplify its voice and encourage the public to participate more actively.

The model proposed here redefines the conceptual pillars of SC. Its object should not be science as a final product, but science in action, with all its uncertainties and controversies. Likewise, its relationship with the public should not be one-way knowledge transmission, but rather one of mutual enrichment, a dialogue that aims at mutual understanding. Finally, its goal should not be the substitution of everyday knowledge nor to fill the public with scientific knowledge, but to promote intellectual pluralism and an ecology of knowledge. Therefore, the scientific communicator should be understood as a professional who has the specific knowledge necessary to perform this SC.

Beyond this theoretical contribution, this model can inform reflective practices in multiple contexts, such as science journalism, museum education, public engagement initiatives, institutional communication, and digital science platforms. Rather than prescribing methods, it offers analytical lenses to guide decision-making, clarify objectives, and critically assess the relationship between science, publics, and mediation technologies.

Ultimately, this model invites SC to definitively abandon the one-way street that has so long marked its history. By recognising the diverse logics of its constituent spheres and the public as a legitimate interlocutor, SC moves towards building a more resilient and profound trust in scientific culture. Transforming science communication into a pillar for a more just, critical, and democratically engaged society with science is the ultimate hope of this chapter.

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Chapter # 11

INTERMEDIATE PHASE TEACHERS' KNOWLEDGE, BELIEFS, AND CHALLENGES IN PROMOTING SELF-REGULATED LEARNING IN SELECTED SOUTH AFRICAN PRIMARY SCHOOLS

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ABSTRACT

Primary schooling is a key contributor to the ongoing underperformance and broader crisis in South African education, yet despite increasing demands associated with the twenty-first century and the Fourth Industrial Revolution, it has received limited attention in developing self-regulated learning approaches. Self-regulated learning is essential in contemporary education, equipping learners with cognitive, motivational, and behavioural skills for academic success and lifelong learning. Teachers' perceptions, knowledge, and beliefs about self-regulated learning shape classroom practices and learners' opportunities to develop these skills. However, limited familiarity with SRL concepts may constrain teachers' ability to integrate SRL effectively into their teaching. Although the value of SRL is well established in the literature, less is known about teachers' understanding of SRL and their capacity to promote it in South African primary school contexts. This qualitative study explored Intermediate Phase teachers' knowledge of, and beliefs about, the value of SRL. Situated within an interpretivist paradigm, purposive sampling selected fifteen teachers from three primary schools. Data were generated through semi-structured face-to-face interviews. Findings indicate that while teachers recognise the importance of self-regulated learning and their role in fostering it, limited knowledge and training hinder effective implementation, highlighting the need for targeted professional development.

Keywords: pedagogical content knowledge, perceptions, professional development, teachers, self-regulated learning

1. INTRODUCTION

South Africa's primary and secondary schooling system is divided into four structured learning phases: Foundation Phase (Grade R (Reception-3), Intermediate Phase (Grade 4-6) Senior Phase (Grade 7-9) and the Further Education (Grade 10-12). The Intermediate Phase generally includes learners between the ages of 10 and 13. During this phase, learners are introduced to additional subjects such as Natural Science, Social Science, and Technology, and the curriculum becomes more academic and structured. According to the National Policy on Promotion and Progression (2015), learners may not fail more than twice within any phase of schooling. This policy aims to ensure that learners within each phase remain broadly within the same age group (Agbenyegah, 2022).

Primary schools are the primary source of the South African school education crisis and the issue of low academic performance, according to the National Education Evaluation and Development Unit's (NEEDU, 2018) summary report (Agbenyegah, 2022). In the NEEDU (2018) report, the Minister of Basic Education acknowledges the crisis in South

African school education, noting that the primary schools, which have received little attention, are a fundamental cause of this underperformance. Moreover, amidst the education crisis, primary schools have not had enough attention to keep up with the Fourth Industrial Revolution and education.

The term self-regulated learning gained prominence in the 1980s (Paris & Winograd, 1990). Since then, self-regulated learning skills have become increasingly important in both classroom contexts and beyond, as they equip learners with the knowledge and competencies required for academic success and lifelong learning (Taranto & Buchanan, 2020). Early pioneers of self-regulated learning research, such as Zimmerman (2002, p. 14), define self-regulation as “self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals,” while Paris and Paris (2001, p. 89) conceptualise self-regulated learning (SRL) as emphasising learner autonomy and control, whereby individuals monitor, direct, and regulate their actions towards goals of information acquisition, the expansion of expertise, and self-improvement. Self-control in learning environments, aligned with SRL behaviours, has been shown to enhance learners' problem-solving abilities, academic achievement, intrinsic motivation, and task interest (Schunk & Zimmerman, 2008). Importantly, more recent scholarship continues to draw on these foundational conceptualisations of SRL. For example, Fuentes et al. (2019) describe SRL as a process through which learners actively take responsibility for their learning by regulating their behavioural, emotional-motivational, cognitive, and metacognitive processes in pursuit of academic goals.

Within school contexts, SRL has consistently been associated with improved problem-solving skills, higher academic achievement, increased intrinsic motivation, and greater task interest (Perry et al., 2006). The application of SRL strategies has further been shown to enhance learners' academic performance and strengthen their capacity to develop lifelong learning skills (Bandura, 2015). However, although SRL can support learners in developing knowledge and skills more effectively, the use of self-regulatory processes does not automatically result in high levels of performance. Schunk (2008) cautions that an exclusive reliance on SRL to improve learner achievement may be insufficient, as optimal learning requires a balance between external support and self-directed practice. This positions teachers as key agents in the development of learners' self-regulated learning skills and in providing structured opportunities for independent learning (Zimmerman, 2006, cited in Jossberger et al., 2010). Consequently, educational researchers worldwide have emphasised the importance of fostering learners' capacity to self-regulate their thoughts, motivation, cognition, and behaviour in preparation for the expanding knowledge base, evolving skill demands, and increasing complexity of challenges they will encounter throughout their lives (Zimmerman, 2002; Bandura, 2015; Cleary & Zimmerman, 2004; Schunk & Zimmerman, 2008).

How teachers view SRL has a significant impact on how learners acquire motivation for learning, autonomy, and successful study techniques for academic success (Schunk, Pintrich, & Meece, 2014). Fostering teaching and learning environments that encourage SRL, self-directed, and lifelong learning require acknowledging and improving teachers' perceptions of SRL because teaching practices are directly impacted by teachers' views and understanding of SRL (Kramarski & Heaysman, 2021; Ehlers, 2022). Teachers may find it difficult to incorporate SRL practices into their classes if they are unfamiliar with the concept of SRL or lack trust in them (Greenquist-Marlett, Bol, & Hill, 2025). Numerous studies support the importance of helping learners develop self-regulated learning skills, therefore it is imperative to ascertain if teachers understand the concept of SRL and have the pedagogical content knowledge necessary to support and guide their learners to develop SRL skills

(Greenquist-Marlett et al., 2025; Kramarski & Heaysman, 2021). Self-regulated learning is thus an essential educational priority due to the move toward learner-centred approaches and the increasing demand for autonomous, critical thinkers.

In the summary report of NEEDU (2018), the poor performance of South African primary schools is blamed on the persistent overinvestment in Grade 12 results when the largest education investment should really be in the early school grades. Due to overinvestment in Grade 12 results, research that focus on South African primary school teachers' understanding and beliefs and practices about SRL is minimal, which makes this study essential. South Africa has significantly fewer SRL studies compared to the rest of the world (Alharbi et al., 2011; Zimmerman, 2013). As noted by Schulze and Van Heerden (2015), most SRL research, both locally and internationally, tends to focus more on higher education rather than on primary and secondary education. The investigation in this study may add to the limited knowledge on SRL use in primary schools in the South African basic education context.

The two research questions that guided the study are: (1) What do Intermediate-phase primary school teachers know about self-regulated learning, and what are their beliefs regarding its value? (2) How do Intermediate-phase primary school teachers in South Africa perceive their roles in developing self-regulated learning within the context of South African primary school classrooms. In line with these questions, the main aim of this study was to explore Intermediate-phase primary school teachers' knowledge of self-regulated learning, their beliefs about its value, and their perceptions of how they develop self-regulated learning in South African primary school classrooms. This investigation furthermore aims to enhance the limited understanding of teachers' perceptions of SRL within the context of primary school education in South Africa.

1.1. Literature Review

Teachers' perceptions of self-regulated learning (SRL) are shaped by a complex interplay of factors, as highlighted by various studies (Greenquist-Marlett et al., 2025). Karlen et al. (2023) emphasize that beliefs, attitudes, and prior knowledge of SRL strategies interact to form teachers' understanding and beliefs about SRL. Central to this process are teachers' general beliefs about education and life, which influence their attitudes and subjective norms. These beliefs often shape teachers' autonomy in teaching and learning and their willingness to adopt new teaching strategies, making it challenging to dissociate their personal views from their professional practices (Dignath-van Ewijk, 2016).

Several types of beliefs play a critical role in shaping teachers' engagement with SRL. Dignath-van Ewijk (2016) identifies three primary categories namely epistemological beliefs, which pertain to teachers' views on knowledge and learning systems. Also, beliefs about SRL promotion, which reflect their perceptions of instructional strategies related to SRL; and lastly self-efficacy beliefs, which relate to teachers' beliefs in their capabilities, confidence and motivation to develop and foster SRL skills in their learners. Teachers with strong SRL skills themselves are more likely to value and successfully nurture learners' SRL skills, as they see its importance through their own experiences. Intrinsic factors, such as teachers' competence in their own SRL skills, motivation, and self-efficacy, also play a crucial role in their perceptions and knowledge of SRL. Hirt et al. (2022) for example, found a positive correlation between teachers' intrinsic interest in SRL and their self-reported promotion of these skills in the classroom.

However, even when teachers value SRL, limited pedagogical content knowledge, low motivation, or a lack of confidence can hinder their role as agents of SRL (Greenquist-Marlett et al., 2025). Teachers' theoretical knowledge and comprehension of the

fundamental ideas of SRL are included in content knowledge about SRL, which might be related to terminology, theoretical models, methods, and SRL components like metacognition. Teachers' pedagogical content knowledge concerning SRL is a component of their knowledge about promoting SRL. This includes teachers' understanding of how to help learners develop strategic skills and the several teaching strategies they can utilise to enhance SRL (Karlen et al., 2023). Research has shown that teachers who lack both content and pedagogical content knowledge of SRL have a particularly poor understanding of instructional strategies that can support SRL. Such teachers mostly use transmission teaching approaches and teacher-directed activities for subject matter learning rather than encouraging SRL skills (Geduld, 2019).

Recent studies found that despite recognizing the importance of SRL in learners' self-regulatory activities, many teachers struggle to explicitly teach or model these skills in the classroom (de Boer et al., 2018; Dignath & Büttner, 2018). According to Spruce and Bol (2015) a significant gap between teachers' positive perceptions of SRL and their practical knowledge of its strategies. This misalignment between beliefs, knowledge, and practice often fails to foster SRL effectively in learners. Moreover, teachers' mindsets significantly influence their approach to SRL (Karlen et al., 2023). Some teachers hold personal beliefs and fixed mindsets that their learners are incapable of attaining SRL skills, which further limits their willingness to support learners' academic achievement and lifelong learning skills by implementing SRL skills (Spruce & Bol, 2015). On the other hand, teachers with a growth mindset are more likely to believe that both their teaching and their learners' SRL abilities can improve over time, fostering a more supportive learning environment for SRL development (Karlen et al., 2023).

Pre-service and in-service training play a critical role, as explicit instruction in SRL fosters an appreciation of its importance. Teaching experience also matters, with veteran teachers often having developed SRL strategies over time, while novice teachers may need additional guidance. The school's culture, policies, and ethos can either support or hinder efforts to promote SRL (Ehlers, 2022), as can the curriculum's emphasis on learner autonomy, metacognitive skills, and self-assessment. Teachers' beliefs about their learners' abilities, motivation, and prior knowledge significantly impact their SRL approach, while their own self-regulation skills can shape their effectiveness in fostering these skills in learners (Spruce & Bol, 2015). Collaborative environments, access to resources, and support systems enhance teachers' ability to implement SRL strategies, and staying current with research and engaging in ongoing professional development further refines their practice (Geduld, 2019). These factors can influence teachers' understanding, beliefs, and practices related to SRL, shaping their ability to promote SRL in their learners.

2. RESEARCH DESIGN AND METHODOLOGY

The research paradigm, interpretivism, encompasses this qualitative study. Proponents of the interpretative paradigm believe reality is created by subjective perceptions. According to Maree (2016), the interpretivist paradigm serves as the foundation for any study that examines the perspectives and opinions of both individuals and groups regarding a given phenomenon. This study is appropriate for an interpretivist paradigm because it explores the lived experiences, attitudes, and viewpoints of individual primary school intermediate phase teachers, as well as their understanding of SRL.

The empirical inquiry was approached with a qualitative research design in the form of a phenomenological study to explore what intermediate-phase primary school teachers know and believe about the value of self-regulated learning. Phenomenology is a branch of

philosophy aiming at describing and analysing the phenomena, the way things appear or look like. The basic purpose of phenomenology is thus to reduce individual experiences with a phenomenon to a description of the very nature of the thing. This study has some elements of a phenomenological study that enabled the researcher to explore a real-life situation, namely the daily experiences of teachers in their classrooms, and to develop a composite description of the essence of the individuals' experiences (Emiliussen, Engelsen, Christiansen, & Klausen, 2021, p. 1). The phenomenological study enabled the researchers to explore real-life situations, and the experiences teachers encounter in their daily teaching and learning in the classroom, and to develop a composite description of the essence of the individuals' experiences (Agbenyegah, 2022).

A purposive sample of fifteen teachers was selected from three primary schools in the Lejweleputswa District in the Free State. The purpose with the small sample was not to generalise the findings of the study, but to gain rich, detailed, and contextualised understanding of Intermediate-phase primary school teachers' knowledge of self-regulated learning, their beliefs about its value, and their perceptions of how they develop self-regulated learning in South African primary school classrooms. Participants were selected based on the criteria that they were qualified teachers, permanently employed at the selected schools, and teaching different subjects in the Intermediate Phase (Agbenyegah, 2022).

Data was gathered through single, individual, semi-structured interviews with participants. To analyse the data using inductive coding, we employed a thematic approach and content analysis. Content analysis is defined as a systematic, replicable technique for grouping many words of text into fewer categories based on explicit rules of coding (Maree, 2016). The audio recordings of the interviews were transcribed so that the information gathered from the participants could be available in writing to assist in the coding process. We read through the transcribed interviews many times, which made it easier and quicker to retrieve relevant data related to the thematic ideas we wanted to create. The data was coded by locating text segments and assigning a code label to them (Saldana, 2016). Categories of information were noted and identified so that relationships in the data could be examined for contradictions and similarities. We analysed one category at a time and focussed on the contents of each category intently. To interpret the results and draw meaning from them, we compared and contrasted, noted patterns and created themes from the raw data and clustered them. Legal authorities, including the Free State Provincial Department of Education and the participating school principals, granted permission to conduct the research following ethical approval from the university (NWU-01909-20-A2) under whose auspices the study was undertaken. All participants provided informed consent and participated voluntarily. All ethical standards were strictly adhered to throughout the study.

3. DISCUSSION OF FINDINGS

All participant responses were considered during the analysis process; however, only those verbatim quotes that most clearly captured the essence of each theme were included for illustrative purposes. To ensure anonymity codes were used to identify participant responses. P3S2 for example identifies participant 2 from school 3.

Based on the responses relating to participants' knowledge and beliefs of SRL one main theme, Knowledge and beliefs of SRL, was created.

Participants' knowledge and beliefs of SRL

The main theme and the five sub themes constructed give insight to participants' knowledge and beliefs of SRL. The five sub themes are: (1) Prior knowledge of the concept of self-regulated learning, (2) comprehension of the concept self-regulated learning, (3) the value of SRL for academic learning, (4) instruction to utilise and develop self-regulated learning, and (5) the roles of teachers to develop and enhance self-regulated learning.

Prior knowledge of the concept of self-regulated learning

Participants responded as followed when asked if they had practical or theoretical knowledge on how to develop SRL skills in learners: *There was no training that I received on self-regulated learning; it is the teacher who must take an initiative by learning more, going to the internet on what strategies to use when I teach learners (P5S2).*

Another two teachers said: *No, the curriculum we did that time was different from the one we are doing now but I must say we also like learners to work on their own, to be independent and not always do everything for them (P4S2).*

No, I was trained on how to teach learners using different teaching strategies and methods, but nothing on self-regulated learning (P2S2).

The sub-theme reveals that the teachers' (P3S2, P2S3, P1S2, P4S3, P4S1, P3S3, and P2S1) knowledge and perceptions of SRL are quite limited. Out of 15 participants, only four (P1S1, P3S1, P1S2, P2S2) had prior knowledge of SRL mostly obtained through workshops: *Yes, I came across this strategy during the workshops that I attended (P1S1).* This indicates that formal training on SRL is scarce among the teachers, which may hinder their ability to foster SRL skills in their learners effectively. It can be concluded that a significant number of participants (P1S1, P4S1, P3S1, P4S1, P5S2, P4S3) were either unaware of SRL or had vague, uncertain notions about it, or did not pay attention when the concept was discussed in their teacher training. This is how one responded: *No, I do not know anything about self-regulated learning or even heard about it (P4S1).* This lack of understanding and gap in awareness can negatively impact their instructional practices, as teachers who are not knowledgeable about SRL may struggle to identify and develop these skills in their learners (Zimmerman, 2000). Consequently, this sub-theme underscores the importance of professional development in SRL for teachers, as it is essential for creating a conducive learning environment that nurtures learners' SRL.

Comprehension of the concept self-regulated learning

The participants who demonstrated an understanding of SRL described it as a process or strategy that learners use when they learn. The following are how the participants explained their understanding of SRL: *Self-regulated learning is to have control, you take responsibility of your work, and you set goals (P1S3).* *Yes, teaching self-regulation in the classroom is important because the emotions and cognitive areas of the brain may not reach the full potential if children do not continually practice at young age. Self-regulated learning helps to support the children ability to handle their emotions and reactions to new situations (P2S3).* *Self-regulated learning starts from babies to toddlers, pre-school years, adulthood. It is lifelong learning whereby you are able to monitor the emotional state of learners, e.g. frustrations, whether they are coping or not (P3S1).* These participants have a growth mindset towards the development of SRL and will be more likely to develop supportive learning environments for SRL development (cf. Karlen et al., 2023).

The value of self-regulated learning for academic learning

The following are two examples of teachers' responses: *...if you can see the world outside now, needs people who are motivated and do things on their own (P3S2).* *Learners*

should be made more interested in what I'm teaching, they must be inquisitive, I must push them and give them ideas that there is more to what I'm teaching them (P5S2). The participants also indicated that teachers should play a crucial role in guiding learners properly and avoid frustrating learners: *Teachers should prepare their lessons because there are learners who are a step ahead and can embarrass them if they did not properly plan their lesson. Some learners can even correct teachers. Teachers should play a role to guide learners properly and avoid frustrating them (P5S1).*

According to the responses, teachers perceive SRL as valuable for academic achievement and developing confident, knowledgeable learners. They believe SRL enables learners to work independently and take ownership of their learning. Teachers also recognize their role in guiding learners properly, preparing lessons, and avoiding frustration, which can have a positive impact on learners' academic achievement and lifelong learning skills.

Instruction to utilise and develop self-regulated learning

The majority of teachers did not receive training on how to develop SRL skills in learners during their initial teacher training or subsequent workshops. *There was no training that I received on self-regulated learning; it is the teacher who must take an initiative by learning more, going to the internet on what strategies to use when I teach learners (P5S2).* Another one concurred: *No, I was trained on how to teach learners using different teaching strategies and methods, but nothing on self-regulated learning (P2S2).* Only two teachers (P1S3 and P1S1) reported receiving some information on SRL, and this was during their further studies or teaching certification programs. Teachers feel that they lack knowledge on how to develop SRL skills in learners and believe they need to take initiative to learn more, such as through online resources. The teachers' educational programs and training focused more on content-area knowledge and pedagogical methods rather than principles of learning, development, and motivation, which may have contributed to their lack of knowledge on SRL (Geduld, 2019).

Obstacles to positive teacher beliefs about self-regulated learning

This theme revealed the participants' responses of factors that negatively influence their perceptions of SRL. Six participants (P1S1, P2S1, P4S1, P5S1, P2S2, P5S3) indicated that time constraints are a challenge. P2S2 responded: *Time is a challenge because we are forced to cover the curriculum.*

The following verbatim quotes encapsulate their negative experiences: *I have never received any support or workshop on SRL; I do everything on my own (P2S3).* *The majority of learners in my class do not do their homework... (P2S2).*

Overcrowding in classes is a problem, my class has about 50 learners, and it is very difficult as a teacher to give all of them individual attention (P4S1).

Lack of resources, in terms of textbooks, posters, atlases, because I am also teaching Social Sciences, we don't have a globe to show learners the world (P5S3), and

I don't really involve parents because it's actually a waste of time for me because you call parents, sometimes they don't come, when they come if you tell them problems you have regarding their children, they will just say they will be involved but they don't (P4S1).

A lack of SRL training and professional development, challenging students, overcrowding, inadequate resources, and a lack of parental participation are some of the causes or barriers participants face daily in public schools. These highlighted challenges were repeated by most participants, making their sense of low self-efficacy to promote SRL visible. Without proper training, teachers may not have the necessary knowledge and skills to implement SRL strategies effectively, leading to a lack of confidence and negative beliefs about their ability to develop SRL skills in learners. When learners are not motivated to learn

or take responsibility for their own learning, it can be discouraging for teachers and make them question the effectiveness of SRL strategies. Overcrowded classrooms can make it challenging for teachers to provide individualized attention and support, which is essential for developing SRL skills, consequently, this may lead to frustration and negative beliefs about the feasibility of SRL in the common overcrowded public schools. Moreover, with heavy Curriculum Assessment Policy Statement (CAPS) curriculum demands and limited time, teachers may feel that they cannot devote sufficient time to developing SRL skills in learners, leading to negative beliefs about the prioritization of SRL. Limited resources can hinder teachers' ability to create engaging and effective learning environments, which are essential for promoting SRL skills. This can lead to negative beliefs about the feasibility of SRL in under-resourced public schools. Beyond these institutional constraints, teachers' perceptions of parental involvement further shape their beliefs about the viability of SRL, as perceptions of limited parental involvement may leave teachers feeling solely responsible for learners' development, thereby undermining confidence in SRL strategies that rely on parent-school collaboration.

4. FUTURE RESEARCH DIRECTIONS

The Lejweleputswa District in the Free State province is big and has primary schools situated in rural villages, farms, towns, and townships. A similar study could be conducted throughout the whole province to find out how teachers develop SRL in primary schools. The research could usefully be extended to Foundation Phase teachers, because they are the ones who should lay the foundation for SRL, and there is a need to find out how they develop learners' SRL. The research could also include subject advisors, who are the curriculum experts and who are expected to be knowledgeable on how to guide teachers on implementing the curriculum effectively.

5. CONCLUSION

The main aim of this chapter was to explore what Intermediate-phase primary school teachers know and believe about the value of self-regulated learning. This study has found that participants' perceptions of SRL are influenced by a dynamic interplay of epistemological beliefs, pedagogical training, self-efficacy beliefs, the perceived value of SRL, and contextual barriers in their teaching contexts. The findings help to explain why the underdeveloped epistemological beliefs about learning and the nature of SRL, poor instructional knowledge to promote SRL, and low self-efficacy beliefs in abilities to promote and nurture SRL remain a challenge in many schools. Teachers who demonstrate these characteristics have negative perceptions about the feasibility of developing and nurturing SRL in their learners.

The teachers who participated in this study may not have a deep understanding of SRL, but they have a positive perception of its potential benefits and recognize the importance of a supportive learning environment for its implementation. This suggests that teachers are open to learning more about SRL and are willing to adapt their teaching practices to promote SRL, given the necessary resources and support. Overall, teachers view themselves as facilitators of SRL, recognizing the importance of empowering learners to take charge of their own learning and development.

There is a clear need for targeted professional development on SRL for teachers to address these issues. In the absence of professional development, primary school teachers may remain unprepared to support their learners effectively, resulting in long-term

educational consequences, including learners being ill-equipped for future academic and workforce challenges, which can perpetuate reliance on external guidance. The lack of knowledge about SRL among teachers has negative implications for learners' adequate SRL skill development which are crucial for academic success. Teachers unfamiliar with SRL may also fail to implement effective SRL teaching strategies and conducive learning environments which can result in fewer opportunities for learners to practice self-regulation and fostering a passive learning environment. This knowledge gap can also reduce teachers' awareness of learners who struggle with SRL, which in turn can result in insufficient support that negatively affects learner engagement, motivation and academic performance, leaving learners unprepared and disempowered for taking responsibility for their learning and other critical lifelong learning skills.

6. CONTRIBUTION OF THE STUDY

This study makes theoretical, methodological, and practical contributions to self-regulated learning research. Theoretically, it strengthens understanding of how a selected group of South African Intermediate phase teachers' knowledge and beliefs shape the development of SRL in primary school contexts. Methodologically, this study demonstrates the value of qualitative, interpretivist inquiry for capturing teachers lived experiences of SRL. Practically, the findings reveal critical gaps in teachers' SRL knowledge and training, highlighting the need for focused professional development and curriculum support to enable effective implementation in South African primary schools. It also captures how teachers in South African primary schools understand and enact SRL in practice amidst contextual constraints (such as curriculum demands, assessment pressures, and resource limitations) that shape teachers' ability to foster SRL in diverse South African classrooms. Moreover, the study Offers evidence-based insights that can inform teacher professional development, initial teacher education, and curriculum support initiatives, particularly within the Intermediate Phase.

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Chapter # 12

ARITHMETIC REPETITION IN THE TEACHING AND LEARNING OF ALGEBRA AND FUNCTIONS IN UPPER SECONDARY SCHOOL

Reality status and development directions

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ABSTRACT

This study examines students' learning of arithmetic–algebra content, focusing on the transition from prior arithmetic knowledge to algebra in relation to how repetition is organized in teaching. The focus was on repetition of arithmetic content, as well as arithmetic repetition–concept shifts into new learning contexts, including algebraic expressions, equations, and the concept of function. In this study, teaching and students' subject-specific learning were analyzed according to the methodological design of Freudenthal's didactical phenomenology, with a focus on the relationship between the teaching of arithmetic and algebra, and Bernstein's conceptualization of the repetition–without–repetition approach, which concerns how prior knowledge should be systematized and integrated with new knowledge. The study illustrates that students' prior knowledge is used to a very limited extent in teaching and in a one-sided manner. The teaching of algebra is seen as an isolated act and has no conceptual connection to students' arithmetic knowledge. The following chapter sets out recommendations to address this problem and outlines an alternative approach to the teaching and learning of algebra and functions that incorporates repetition. The study highlights the importance of developing an alternative approach to “get through” learning-oriented repetition and teaching, grounded in a psychological perspective.

Keywords: arithmetic repetition, systematic repetition, learning-based teaching, algebra learning, psychology, students' learning, Freudenthal's didactical phenomenology, Bernstein's repetition-without-repetition approach.

1. INTRODUCTION: CONCEPTUAL RESEARCH CONTEXT

Students' knowledge transition from the final year of primary school to secondary school is perceived as problematic and challenging (Jindal-Snape, Symonds, Hannah & Barlow, 2021). One reason for this is that students often come from different learning environments, bringing with them different levels of knowledge and different perceptions of mathematics. Moreover, students' prior mathematical knowledge often focuses on calculation, formulas, and memorization (Symonds & Galton, 2014).

Recent discussions about teaching and repetition in Swedish schools are strongly rooted in educational history and teaching culture (Bergsten, 2002; Östergren, Träff, Elofsson, Hesser, & Samuelsson, 2023). Historically, students often learned subject-specific content through counting and repetition of prior knowledge in isolation, without a connection to new knowledge (Karlsson & Kilborn, 2023a, 2025). In Swedish primary schools, students' learning of mathematics often focuses on rote memorization, for instance, of multiplication

tables, facts, and formulas, instead of promoting conceptual learning (Karlsson & Kilborn, 2023b). At the same time, rote learning without an understanding of mathematical concepts is meaningless, as it cannot be carried over to a systematized context or extended into new knowledge. The same issue has been highlighted by several international researchers such as Katzoff, Zigdon, and Ashkenazi (2020), as well as Yuliandari and Anggraini (2021). This was also illustrated in a survey study of pre-service teachers' prior mathematical knowledge in relation to a repetition test at the start of their mathematics studies in teacher education. The study clearly showed that knowledge gained through rote memorization is not available and difficult to apply when solving text-based and problem-solving tasks (Karlsson, 2015). Learning with a focus on low cognitive domains, such as memorization and calculations, does not lead to mathematical generalization or an understanding of mathematics (Smith & Stein, 1998).

Moreover, primary school mathematical activities are mostly dominated by lower-level cognitive learning, rote knowledge, and numeracy (Carmichael, 2015). This can lead to problems when students repeat arithmetic operations or when algebra and functions are introduced, which may have consequences for their continued studies of mathematics. To resolve this, it is necessary to activate, systematize, recapitulate, and extend previous learning through optimal conceptual teaching. Hence, repetition based on students' prior knowledge, applied in a new, broader context, is a key factor in organizing students' knowledge, understanding, and relational thinking (Skemp, 1976). According to Brinkmann (2017), repetition is a didactical strategy in teaching that aims to actualize and extend the knowledge that students already have or had in the past.

It is not sufficient for students to work with mathematical tasks they have never understood. A study of students' learning of operations with rational numbers in grades 7–9 showed major deficiencies among students in grade 7 (Baldemir, Tutak, Nayiroglu, & Suzen, 2023). Moreover, studies such as Avcu (2024) illustrate that students face challenges in learning rational numbers. Many of these challenges were still present in grade 9, where most students had insufficient knowledge or lacked conceptual knowledge of fractions and related concepts. As a result, students had limited opportunities to transfer knowledge from primary to secondary school, which impeded the development of new conceptual knowledge of algebra and functions. In other words, continuous repetition, supported by teachers during the teaching process, is required for students to assimilate previous knowledge and establish a framework for learning new knowledge. Knowledge transfer, specifically from primary school to upper secondary school and from arithmetic to algebra, continues to be an important area of research (Matiti, 2022).

Before introducing new learning content, it is important to ensure that students have the prior knowledge necessary to assimilate new mathematical concepts or methods. For some students, it may be enough to recapitulate and systematize what they have already learned (Kania, Fitriani, & Bonyah, 2023). For other students, the gap between prior knowledge and new knowledge to be assimilated is sometimes extensive and requires a new approach to teaching that integrates two interwoven parts: a core based on prior knowledge and a component based on new knowledge. Helping students continuously gain access to relevant mathematical concepts and methods is crucial for teaching in a democratic classroom (Stemhagen & Henney, 2021). To minimize gaps in students' prior knowledge, it is recommended that teachers analyze and review which previously learned content is most important and provide balanced, conceptually grounded teaching. This type of teaching is essential to ensure equal learning opportunities for all students. According to Vygotsky, students' learning occurs through the integration of prior knowledge and new knowledge within a foundation of conceptual continuity, which is crucial for students' knowledge

development (Vygotsky, 1978, 1987). Against this background, it is natural to interpret the meaning of repetition in relation to the meaning of the learning process, not just as a reconstruction of necessary, but not yet acquired, knowledge and skills.

The purpose of this study is to examine how students' repetition of arithmetic concepts is organized in teaching during the first year of upper secondary school in order to extend research focusing on the conditions for students' outcomes in algebra through repetition processes and on the conditions for students' knowledge transition from arithmetic to an algebra learning context. More specifically, the study seeks to address the following research questions:

RQ1: How do teachers organize the repetition process of arithmetic concepts before and within the teaching of algebraic concepts and functions?

RQ2: How do teachers assess students' prior and new knowledge, and what conceptual support do they draw from the relevant textbook when developing a method for repetition?

2. THEORETICAL FRAMEWORK

The theoretical conceptual design draws on Freudenthal's (1973, 1983) didactical phenomenology of mathematical structures and Bernstein's (1996) repetition-without-repetition learning theory. This design was used for the conceptualization of repetition in mathematical instruction.

Freudenthal (1983) highlighted the importance of understanding mathematical concepts, their conceptual meaning, and context. A fundamental didactical and phenomenological analysis of mathematical concepts and structures makes it possible to define mathematics as a science and understand its use and application, particularly in teaching. Understanding the phenomenology of "mathematical structures, knowledge of mathematics and its applications" through didactical phenomenology provides knowledge that can be applied in instruction and in monitoring students' cognitive development and growth. According to Freudenthal (1983), mathematics cannot be taught without ensuring continuity in students' learning and activating their prior experiences. At the same time, mathematical instruction must include realistic mathematical activities (Freudenthal, 1991; Gravemeijer, 1994; Tall, 2004) that provide students with the prerequisites and conditions to learn mathematics according to their own abilities and limitations.

A crucial aspect of Freudenthal's (1983) approach to teaching practice is the emphasis on the individual learning process and on students' learning needs in relation to the individual development and progression of knowledge. The significant impact algebra has on learning is the result of the conceptual expansion of arithmetic and the "intuitive" methods primarily used by younger students. Teaching elementary arithmetic as numbers and their operations is key to practicing algebra and using algebraic rules and methods (Freudenthal, 1973). At the same time, algebra mastery occurs on another level of knowledge and requires renewed practice of algebraic methods, as "traditional methods from elementary arithmetic" are not enough. According to Freudenthal (1973), arithmetic and algebra are fundamentally different because arithmetic is "intuitive and close to reality or at least it should be so" (p. 287). Algebra, however, is abstract and grounded in "formal-symbolic methods." To minimize the conceptual difference between arithmetic and algebraic methods, it is important to introduce and apply algebraic methods at an early stage, when students are first introduced to algebraic calculus and algebraic symbols. This kind of didactics can be used, for example, in students' learning of algebra by illustrating how algebraic methods build on the arithmetic they learned in previous grades. In other words, there is a need to create a

bridge between students' prior arithmetic knowledge and new algebraic knowledge, while also incorporating conceptual repetition. This means that the learning of arithmetic in early grades can be organized to create conceptual continuity from whole numbers to rational numbers, and so on. Teaching and learning algebra, as well as the development of students' mathematical skills, is a multifaceted process. At the same time, systematic repetition is essential for providing conceptual continuity and supporting long-term teaching and learning (Tall, 2004). A teaching approach that incorporates principles of repetition can help students systematize and reproduce their knowledge of mathematics, understand the challenges they encounter, and activate effective learning strategies (Gray & Tall, 1994).

Bernstein's (1996) concept of "repetition-without-repetition" (RWR) emphasizes that the repetition process needs to be implemented in teaching continuously, "by every movement," through educational tasks consisting of new learning components (Palatnik, 2023; Shvarts & Abrahamson, 2023). According to Bernstein, repeated practice leads to new ways of thinking.

The conceptual framework for repetition is knowledge development. Bernstein adds that "absolute repetition" (one-by-one) cannot be part of a learning process that aims to develop knowledge successively. This theoretical framework is used in this study to define the conceptual meaning of repetition as a teaching phenomenon and is seen as a logical extension of Freudenthal's (1973) phenomenology.

3. RESEARCH DESIGN

The study was designed with the aim of examining teaching practices in relation to students' learning of algebra and functions, based on how teachers implement the repetition process and the conditions that promote the transfer of students' prior arithmetic knowledge into new knowledge about algebra and functions.

Participants included three upper secondary school mathematics teachers and their three classes, comprising a total of 94 students (34 students in class A, 34 in class B, and 26 in class C).

First, it was important to establish a constructive discussion with the teachers about the teaching process, the structure of the content, and planning for repetition to support students' learning through repetition, by linking new knowledge to prior arithmetic knowledge. This was arranged through discussions between researchers and teachers, based on the researchers' PowerPoint presentations and an analysis of tests intended as a basis for the repetition of arithmetic and algebraic concepts. The tasks were selected from the relevant textbook (Szabo et al., 2021).

Second, the collected data were used to create a holistic picture of the repetition process and teaching focusing on students' learning, as represented by the conceptual design for the study in the Figure 2 below, in Section 4.1, "Conceptual design for teaching and learning."

The researchers designed a qualitative methodology, including group discussions with the teachers and individual discussions about tests used as a basis for repetition. This led to reflective, interactive discussions between researchers and provided insight into teachers' development through a reflective process.

The key arithmetic content for repetition included whole numbers, rational numbers, and powers while the relevant teaching content for algebra included algebraic expressions and linear and rational equations. The main component for arithmetic repetition and algebra teaching was Freudenthal's (1973) didactical phenomenology of whole and rational numbers, as well as his perspective on the number concept, applied arithmetic, and the development of number concepts into algebraic methods. A theoretical conceptualization of inverse

operations and algebraic concepts was also used (Karlsson & Kilborn, 2024), as well as the didactical structure for teaching arithmetic, algebra, and functions. The standard arithmetic repetition test, constructed and used by teachers, is illustrated in Figure 1.

Figure 1.
Standard arithmetic repetition test.

1)	Solve: 1a. $2 + (-4)$; 1b. $(-3) + (-7)$; 1c. $4 - (-2)$; 1d. $(-6) - (-4)$; 1e. $(-7) + 5 - (-4)$; 1f. $(-6) + 3 - 4$.
2)	Write in exponential form: 2a. 575 000 000; 2b. 0.000 04; 2c. 301.2.
3)	Solve: 3a. $24 - (-8 - 13)$; 3b. $5 - 2 \cdot (-3)$.
4)	Solve: 4a. $\frac{1}{5} + \frac{3}{5}$; 4b. $\frac{2}{3} + \frac{1}{6}$; 4c. $\frac{2}{5} \cdot \frac{3}{4}$; 4d. $12 \cdot \frac{2}{3}$.
5)	Solve: 5a. $7^3 \cdot 7^2$; 5b. $7^2 \cdot 7^{-5}$; 5c. $7^2 + 7^1 + 7^0$; 5d. $7^{-7}/7^3$.
6)	What number is x? $3^7 \cdot 3^4 = 3^x$.
7)	Solve: 7a. 5^{-2} ; 7b. $3^2 \cdot 4^{-2}$.
8)	Solve: 8a. $4^{\frac{2}{3}} \cdot 4^{\frac{4}{3}}$; 8b. $\sqrt{9} + 9^{\frac{1}{2}}$.
9)	Solve in potencies form: 9a. $\frac{(7^3)^2 \cdot 7^4}{7^5}$; 9b. $\frac{100}{0.001}$.
10)	Solve: 10a. $2.51 \cdot 10^3$; 10b. $3 \cdot 10^{-2}$; 10c. $4.23 \cdot 10^{-7}$.
11)	Solve: $(25^{\frac{1}{2}})^3$.
12)	Write in base 5: $25^8 \cdot 5^{11}$.
13)	Simplify as far as possible: $2^{-3} + (\frac{3}{2})^3$.
14)	Solve the equation: $2^n + 2^n + 2^n + 2^n = 2^{30}$.
15)	Solve in exponential form: $27^{-2/3}$.

A mixed-methods methodological design was used in the data collection process. A *quantitative* analysis was used to examine the content of teacher–researcher discussions, researchers’ participatory observations, reflective journals, pre-tests prior to repetition, arithmetic-algebraic-functions learning tasks, and analyses of learning tasks in the relevant textbook.

The joint discussions provided insights into teaching practice, teachers’ experiences and perceptions of practical classroom work, as well as their knowledge of teaching from their own teacher–education programs. In the present study, the key components of the methodology were also the *qualitative* analysis of the collected data and the research questions, which aimed to identify significant empirical findings. A qualitative analysis includes teachers’ written teaching plans concerning arithmetic repetition and algebra-function content, the analysis of students’ answers to a repetition test in a focus group, and the analysis of teaching content such as teaching-learning tasks and the repetition content in the textbook in use. To further analyze students’ performance on the repetition test, a focus group of 10 randomly selected students was constructed. Their answers to the respective tasks in the repetition test were examined both *quantitatively and qualitatively*.

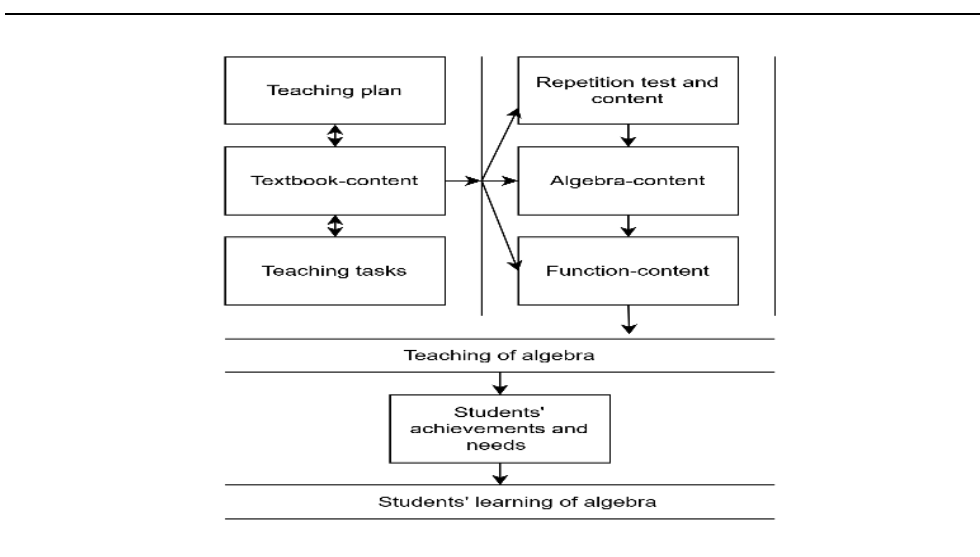
To optimize the process, the researchers actively participated in discussions on the planning of teaching and learning tasks, helping teachers systematize and reflect on the relevant content. Researchers also contributed PowerPoint presentations and information about current research, as well as its practical implementation in new teaching strategies, teaching methods, and content.

The methodology added conceptual meaning to the study, addressing subject-specific repetition, the presentation of new content, the profound conceptual learning of arithmetic-algebraic-function concepts, and the crucial connection between concepts in teaching and learning (Chick, Baker, Pham, & Cheng, 2006). The researchers also examined the practical application of repetition in the classroom environment in relation to the applicable design and methodology, as well as arithmetic-algebraic teaching and learning content, repetition tests and tasks, and their relationship to students' learning of new content (Timperley & Alton-Lee, 2008). The research methodology led to a conceptualization of the repetition process that can provide a spectrum of outcomes, including the expansion of students' prior arithmetic knowledge and the development of a theoretical framework that contributes to algebraic learning.

3.1. Conceptual Design for Teaching and Learning

The conceptual design developed by the researchers and used in the study is illustrated in Figure 2. The design forms the basis for the structure of the results section.

Figure 2.
Conceptual design of the study.



The conceptual design for the study, considering the repetition process and students' learning, is rooted in Bernstein's repetition-without-repetition (RWR) approach.

3.2. Ethical Considerations

Participants were informed about ethical principles, including trustworthiness and anonymity. Data from teacher discussions were treated confidentially, and conclusions regarding instructional planning were based on objective sources such as written lesson plans. Students' arithmetic test results were anonymized. At the start of the study, teachers were briefed on procedures for collecting, interpreting, and using qualitative and quantitative data for research purposes. The subject-specific content of the textbooks was discussed with teachers in relation to conditions for students' learning of algebra through repetition, framed

within a clear research-theoretical context. Ethical standards followed the Swedish guidelines for Good Research Practice (Swedish Research Council, 2024), which outline principles for research integrity and ethics.

3.3. Analysis

The collected data were categorized in relation to the research questions and interpreted carefully. Teachers' reflections on their experiences and perceptions of practical classroom work were interpreted in relation to teaching current content, mostly based on a written teaching plan, how teachers chose teaching-learning tasks, including tasks in the textbook and tasks in the repetition test, as well as their analysis of students' results in the repetition test and subsequent planning of teaching. The focus of the analysis was the current teaching, including the written teaching plan and the content of the repetition test, teaching-learning tasks, and teachers' analysis of students' achievements, needs, and knowledge development.

4. FINDINGS

4.1. Finding 1. RQ1

How do teachers organize the repetition process of arithmetic concepts before and within the teaching of algebraic concepts and functions?

At the start of the study, researchers noted that teachers interpreted repetition in teaching as the number of weeks prior knowledge is reviewed. This review period begins with a common test used by all teachers in the same municipality, followed by repetition tasks from the textbook.

As mentioned earlier, teachers noted challenges in teaching subject-specific content based on students' outcomes on the test. When researchers asked about students' knowledge, the teachers' answers were consistently based on the content in the textbook. Over time, however, teachers were able to approach teaching from a broader teacher-student perspective.

Arithmetic repetition lasted for five weeks: one week for whole numbers, one week for fractions, one week for decimals, and two weeks for exponents. At the end of the fifth week, the students completed the standard arithmetic repetition test. The written teaching plan for repetition was taken from the first chapter of the relevant textbook and had a variety of goals regarding what students should review and why.

Repeated discussions with teachers revealed that their understanding of repetition was inconclusive and unbalanced, particularly concerning what students should be taught during the repetition phase and how it should support their acquisition of new knowledge. Some of the students had poor results on the repetition tests, which will be discussed later, but this was never noted, and no measures were taken to teach the content after the repetition test based on the students' results.

The teaching and teaching plan were tied to the structure and content of the textbook used. In discussions with the teachers, it became clear that they always follow the applicable teaching plan and the repetition test.

At the end of the study, researchers noted that the teachers' perceptions of repetition remained focused on the repetition tasks in the textbook rather than a plan for teaching or content goals. Teachers attributed the students' poor performance to textbook content and their previous learning experience. Teachers did not acknowledge their own role in students' learning or their inability to develop an effective learning process. Although five weeks were set aside to revisit and reinforce students' prior knowledge, instruction was dedicated to the repetition of tasks in the textbook with no relation to students' real needs. As a result, the

students' misconceptions were often reinforced, rather than learning strategies to acquire and apply the necessary knowledge. The lack of clear goals and selection of inadequate repetition tasks, combined with the teachers' organization of teaching, had negative consequences for students' acquisition of new knowledge.

The discussions with teachers provided insights into their approach to teaching algebra and functions, revealing that this content was seen as an isolated task. Furthermore, teachers lacked effective strategies to apply, update, and integrate arithmetic repetition content into current teaching and learning. Despite assistance from the researchers, who suggested new teaching approaches to create better conditions for the development of new knowledge of algebra and functions, no changes were made immediately. The teachers' explanation was as follows:

[...] we had a number of relatively broad questions about teaching and learning algebra and [...], we have received guidance and help during the year (2024–2025) to sort and narrow down the different questions and structure possible areas of development going forward. It has been very inspiring and helpful for us to receive this research guidance and help, but above all it has given us new perspectives and tools to develop and think about new ways of teaching.

The teachers' plan for instruction continued to treat algebra and functions as separate entities, without a relational and logical relationship to arithmetic. A likely explanation for teachers' inability to change their approach is that their own education was not adapted to research in mathematics education or contemporary changes in teaching and schooling. An important conclusion is that teachers' actions must be evaluated in relation to students' outcomes and their opportunities to develop new knowledge in an environment that supports knowledge acquisition. The teachers' written reflection was that:

[...] we have had confirmation that many parts of our way of teaching today are in line with what research has shown is effective for students' learning. A concrete activity that has been particularly rewarding during the research has been when we have analyzed mathematical tasks for teaching and learning together with researchers and analyzed repetition test results and created/analyzed diagnoses to follow up on students' learning in a specific area (there has been a particular focus on algebra).

This means that teachers appreciate the development of a new teaching-learning approach that took place together with researchers. Another important point is that teachers need to understand and develop the teaching process through continuous reflections and actions based on how the students have mastered the content. This takes more time than the timeframe for this study, but teachers have good theoretically based presumptions from the current study.

The results show that teachers did not optimally and effectively adapt teaching content before and consider its effect on students' knowledge acquisition during repetition. Against this backdrop, the results highlight the importance of a balanced learning environment, grounded in comprehensive teacher education and a supportive teaching culture within schools.

4.2. Finding 2. RQ2

How do teachers assess students' prior and new knowledge, and what conceptual support do they draw from the relevant textbook when developing a method for repetition?

Results from the standardized test (Figure 1) given after repetition are presented in Table 1. A total of 63 students participated, and the test consisted of 34 problems.

Table 1.
Standard arithmetic repetition test and students' results
(T = task and CA = correct answer).

Whole number and operations								
T	1a	1b	1c	1d	1e	1f	3a	3b
CA	92%	87%	76%	68%	48%	48%	41%	33%

Fractions and operations				
T	4a	4b	4c	4d
CA	94%	83%	71%	55.5%

Potencies and operations								
T	2a	2b	2c	5a	5b	5c	5d	6
CA	70%	44%	41%	89%	68%	22%	55.5%	49%
T	7a	7b	8a	8b	9a	9b	10a	10b
CA	44%	17%	22%	48%	63%	16%	76%	84%
T	10c	11	12	13	14	15		
CA	44%	17%	16%	13%	13%	3%		

In order to interpret the quantitative results from Table 1, a random sample of 10 students' arithmetic test results, similar to a focus group, was selected. This is illustrated in Table 2.

Table 2.
Standard arithmetic repetition test and focus group results
(T = task and CA = correct answer).

Whole number and operations								
T	1a	1b	1c	1d	1e	1f	3a	3b
CA	70%	90%	90%	90%	50%	50%	40%	30%

Fractions and operations				
T	4a	4b	4c	4d
CA	80%	60%	40%	60%

Potencies and operations								
T	2a	2b	2c	5a	5b	5c	5d	6
CA	60%	50%	40%	80%	70%	40%	50%	70%
T	7a	7b	8a	8b	9a	9b	10a	10b
CA	30%	30%	10%	10%	40%	10%	80%	80%
T	10c	11	12	13	14	15		
CA	10%	-	-	-	-	-		

The main difficulties for the students in the focus group (correct answer frequency 50% or less in Table 2) were related to operations with negative numbers (tasks 1e, 1f, 3a and 3b), the multiplication of fractions (4c), converting decimals to exponents (tasks 2b and 2c), and operations with exponents (tasks 5c, 5d, 7a, 7b, 8a, 8b, 9a, 9b, and 10c). Tasks 8a, 8b, 9b, and 10c are related to operations with exponents using negative exponents.

The results illustrate that 15 out of 34 tasks in table 1 and 12 out of 34 tasks in Table 2 had correct answers from more than 50% of students.

A careful analysis of the repetition test could be used as a basis for identifying students' learning needs and difficulties in basic arithmetic. Students' current knowledge is an important component of teaching praxis and forms the basis for the effective implementation of arithmetic repetition, as well as the teaching of algebra and functions. However, the findings from the study show that these were not considered in the teachers' instruction.

Despite researchers presenting the results above in tables 1 and 2 and offering concrete recommendations for developing teaching based on students demonstrated arithmetic knowledge, no changes were implemented.

The teaching of algebra and functions continued without consideration of students' prior knowledge. It was apparent that the teachers needed significantly more time to develop and advance in how to analyze and use the textbook's tasks in the teaching process related to the learning of algebra.

A comparative analysis of the results in tables 1 and 2 yielded the same conclusions. Students struggled with tasks that are important for their continued learning of algebra and functions, namely operations with negative numbers, fractions, and exponents with a negative exponent.

This finding showed that the construction of knowledge has a logical conceptual connection, which was clearly illustrated in the results of the repetition test. Students' inability to understand negative numbers led to negative consequences for further knowledge acquisition, in this case, exponents with negative exponents.

The findings from tables 1 and 2 indicate that teachers need to consider how gaps in students' prior knowledge can be addressed in teaching. The results also show the importance of students' ability to master algebra and functions in a progressive way. It is important that teachers are aware of fact that students' learning is a dynamic process that depends on the instruction they receive.

A total of 63 of 94 students participated in the repetition test, and most demonstrated engagement while completing the tasks. Students' difficulties with the tasks during the five-week repetition period likely relate to previous experiences with learning mathematics.

Textbook and repetition tasks

The textbook has a special 43-page chapter for the repetition of arithmetic tasks, aimed at systematically repeating prior knowledge before algebra is introduced. The subheadings are: Whole numbers, Fractions, Decimals, and Exponents.

The number of tasks intended for this repetition is shown in Figure 3 below. The subheadings (levels 1, 2, and 3) in the textbook show the complexity of the tasks.

The quantitative mapping of the tasks for the repetition of arithmetic shows that the number of tasks on whole numbers, fractions, and decimals is small compared to the number of tasks on exponents.

The same tendency was found in the teachers' test given after the repetition. More emphasis should be given to level 1 arithmetic tasks rather than the equal distribution of tasks between levels and the progressive difficulty of the tasks (see Figure 3).

Figure 3.
Number of repetition tasks in the textbook.

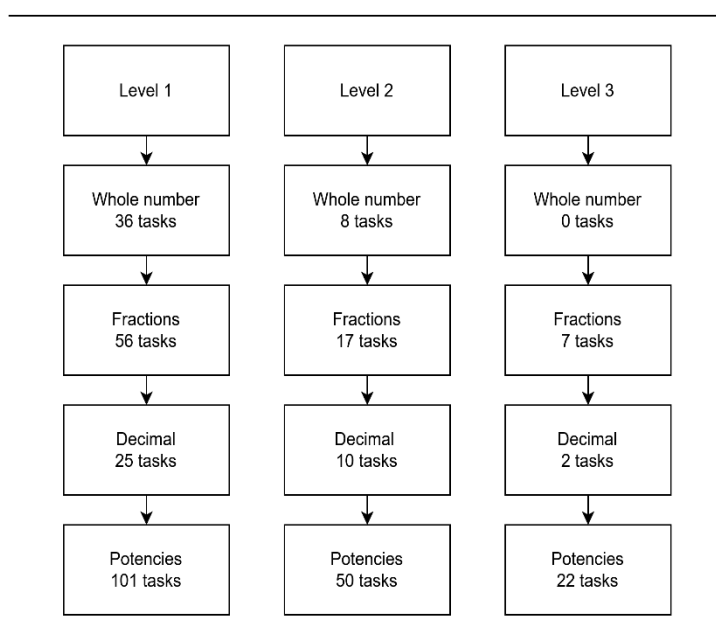


Figure 3 clearly illustrates that the number of tasks in each area and level are varied, though it is not possible to determine the reason for this distribution.

Textbook and repetition of mathematical content

The arithmetic tasks in the textbook have no clear or logical conceptual progression from level 1 to level 3 in relation to the focus and structure of the concepts.

For example, level 1 (p. 14) includes 10 tasks about reusing and extending fractions.

Level 2 contains one task on the lowest common denominator and two tasks on comparing the size of fractions.

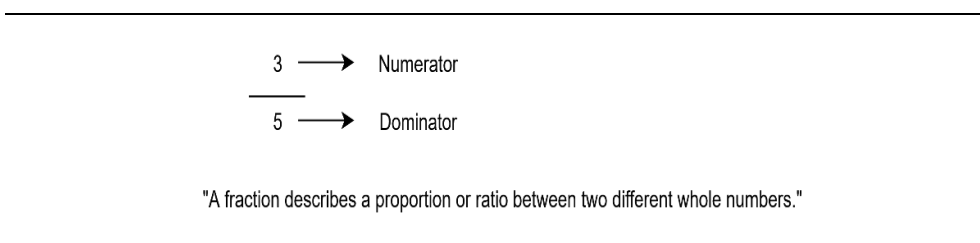
Level 3 includes just one task on the lowest common denominator. There is no logic in this. For example, a comparison of fractions is used to identify the lowest common denominator and should appear at level 1.

This is a poor conceptual transfer from one level to another, and there are similar tasks on level 1 in the example above.

The next question is how definitions of mathematical concepts are introduced in the textbook, for example, the concept of a rational number (fraction). In the textbook, fractions are introduced through a real-world situation, for example: "Three people in a family of five have decided to go on vacation.

This can be expressed with a fraction by writing that: ' $\frac{3}{5}$ of the family has decided.'" This is then illustrated as shown in Figure 4.

Figure 4.
An interpretation of the definition of a rational number or fraction in the textbook.



The definition (an interpretation from the textbook in use) provided in Figure 4 is not correct. A fraction is described only through two selected properties and by a *proportion* or a *relationship* between two whole numbers. The same proportion can be expressed in different ways. In fact, there is no definition at all. In this case, the proportion 3/5 is described only by using a fraction. How should a fraction like $\frac{3}{5}$ be defined? Moreover, the concluding text is reversed: it is a proportion or a ratio between two whole numbers that can be described using a rational number, not the other way around. Another question is how a fraction like $\frac{6}{5}$ could be described with a real-world situation based on the "definition" in the textbook.

As an example, a correct definition of fraction is $\frac{a}{b} = a \cdot \frac{1}{b}$, where $b \neq 0$. To understand this, it is important to know that $\frac{1}{b}$ is the inverse of b . This is important in the next step in order to ensure a conceptual understanding of the formulas for multiplication or division of two fractions.

A qualitative analysis of the repetition tasks shows that most of the instructions for repetition describe *how* to accomplish the tasks, not *why* or *when* they should be accomplished.

5. CONCLUSION/DISCUSSION

This study examined how students' repetition of arithmetic concepts was organized in teaching during the first year of upper secondary school. Many of the findings highlight the importance of research-based teaching responses to repetition. The understanding of how teachers' repetition practices influence students' ability to repeat and systematize prior knowledge, as well as to apply prior knowledge in new learning, is central. The study clearly shows that the teaching process for repeating prior knowledge is not sufficiently developed and does not fully support students' knowledge acquisition or continuity in learning (Bernstein, 1996; Palatnik, 2023; Shvarts & Abrahamson, 2023).

The findings also support the research of Gray and Tall (1994), who highlighted the importance of learning effective strategies as a result of a solid teaching plan and content. Furthermore, Freudenthal (1973, 1983) supports the notion that students' knowledge of arithmetic is a key for learning algebra and the corresponding abstract aspects of mathematics.

The study also has practical implications for teachers, highlighting areas of teaching practice that must be improved and developed, such as addressing students' prior knowledge through a continuous learning process that integrates both prior knowledge and new knowledge (Bernstein, 1996; Tall, 2004).

In terms of content repetition, the study clearly shows that shortcomings in prior knowledge lead to problems in students' continued learning. (Freudenthal, 1991; Timperley & Alton-Lee, 2008). In this context, it is not beneficial for students to repeat algebraic and function concepts if teachers lack progressive strategies for improving students' knowledge through repetition.

The study shows that the balance between teachers' mathematical content knowledge, the choice of repetition content, learning-based teaching, and the careful, analytical use of textbook tasks in teaching creates a crucial "mind-map" for the repetition process, providing a foundation for achievement and knowledge development (Chick, Baker, Pham, & Cheng, 2006; Karlsson & Kilborn, 2024).

Students' results from the repetition test, combined with a number of ambiguities in the textbook and vague concepts and definitions, provide insight into the current conditions for learning. There is a significant divide between teaching content, the content in the textbook, and students' conceptual learning. This clearly shows the importance of teachers' mathematical content knowledge, their ability to plan instruction, analyze students' learning and needs, and, not least, carefully analyze the content in the textbook. The results show that there is an imbalance between the necessary conceptual base students require as prior knowledge and the actual teaching and support from the textbook. This can have a number of negative effects on students' learning of algebra and functions.

One significant advantage of this study is its theoretical and methodological design, which incorporates psychological variables and triangulation in terms of a learning-oriented approach, repetition goals, and the integration of these learning goals into the teaching and repetition of arithmetic content, including its interplay with algebraic and function content. At the same time, it requires certain conditions and the optimal choice of methodology.

This empirical study should be continued, both in an analytical way and by developing a more optimal basis and methodology, including optimal qualitative methods for researching teaching and learning. In addition, teachers' active role and their ability to reflect on and adopt new teaching approaches are essential in this type of research.

In their reflections and discussions, teachers clearly indicated that they face significant challenges related to pedagogical knowledge, such as mathematical content knowledge for teaching. This concerns, for example, how to break down subject-specific content for instruction and how to organize teaching according to students' knowledge development. This has a significant impact on students' overall learning beyond the repetition process. This study highlights the importance of developing an alternative, learning-oriented approach to teaching. The findings from this study are intended to support the preparation of prospective teachers.

At the request of the teachers, this study will continue from the fall of 2025 through the fall of 2026, with a special focus on the design and construction of algebraic tasks based on students' learning.

6. LIMITATIONS

The first limitation of the study is that it was conducted in just one upper secondary school, which provides limited insight into other teaching environments. For this reason, the findings cannot be generalized to other school environments and teaching traditions related

to repetition. The second limitation of the study is that discussion questions were interpreted by researchers without classroom observations.

Adding an observation component in subsequent studies could provide broader guidance for understanding repetition practice in schools.

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Chapter # 13

EXPLORING THE RELATIONSHIP BETWEEN STUDENTS' MATHEMATICS SELF-EFFICACY AND MATHEMATICAL LITERACY

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ABSTRACT

Mathematics self-efficacy—the belief in one's ability to successfully perform mathematics-related tasks—has been consistently linked to improved mathematical performance and literacy. This study investigates the relationship between mathematics self-efficacy and mathematical literacy among Greek students at the end of compulsory education. A sample of 650 students from schools across major urban centers, small urban centers, and rural areas in Greece participated in the study. Mathematics self-efficacy was measured both as a single composite index and through four specific subcategories: (1) self-efficacy in solving abstract mathematical exercises, (2) self-efficacy in addressing real-world problems, (3) self-efficacy in mathematical literacy skills, and (4) self-efficacy in information literacy skills. The study aims to determine whether statistically significant correlations exist between students' performance in mathematical literacy and each of these dimensions of self-efficacy. The findings reveal a statistically significant positive correlation between overall mathematics self-efficacy and mathematical literacy performance. Furthermore, each of the four subcategories also demonstrated statistically significant positive correlations with mathematical literacy outcomes. These results underscore the multifaceted nature of mathematics self-efficacy and its critical role in supporting students' success in mathematical literacy, particularly as assessed in large-scale frameworks such as PISA.

Keywords: mathematical literacy, mathematics self-efficacy, compulsory education, Greece.

1. INTRODUCTION

Self-efficacy refers to an individual's belief in their capacity to achieve desired outcomes through their actions and abilities, functioning as a central motivational mechanism in overcoming challenges and difficulties (Bandura, 1994, 1997). It reflects the confidence individuals hold in their ability to organize and execute the behaviors required to attain specific goals (Delcourt & Kinzie, 1993). According to Bandura (1997), individuals with high levels of self-efficacy approach challenges with greater confidence, often drawing upon strategies that have proven effective in prior experiences. A key distinction between individuals with high and low self-efficacy lies in their persistence and resilience: highly self-efficacious individuals are more likely to persevere after failure and adopt alternative strategies, whereas those with lower self-efficacy may disengage or withdraw (Bandura, 1997; Usta, 2016).

Self-efficacy plays a critical role in students' academic success by shaping both their educational choices and their engagement in learning activities (Pajares & Miller, 1994; Sharma & Nasa, 2014). Within this broader framework, mathematics self-efficacy refers to individuals' beliefs in their ability to effectively engage with and successfully complete mathematics-related tasks, even when confronted with complexity or

difficulty (Fast, Lewis, Bryant, Bocian, Cardullo, Rettig, & Hammond, 2010; OECD, 2013; Schunk, 1991; Stankov, Morony, & Lee, 2014). More specifically, mathematics self-efficacy encompasses students' confidence in managing a wide spectrum of mathematical demands, ranging from understanding fundamental concepts to solving complex and unfamiliar problems (Sharma & Nasa, 2014).

A substantial body of empirical research has consistently demonstrated a statistically significant positive relationship between mathematics self-efficacy and mathematics achievement (Anjum, 2006; Ayotola & Adedjei, 2009a, 2009b; Fast et al., 2010; Goodwin Ostrom, & Scott, 2009; Jiang, Song, Lee, & Bong et al., 2014; Pajares & Miller, 1994). This association has also been well documented with respect to mathematical literacy, particularly within large-scale assessment contexts (Cheema, 2018; Cheema & Galluzzo, 2013; Cheema & Skultety, 2017; Hiller, Kitsantas, Cheema, & Poulou, 2022; Kalaycıoğlu, 2015; Karakolidis, Pitsia, & Emvalotis, 2016a, 2016b; Lee, 2009; Lee & Stankov, 2013; OECD, 2004, 2013, 2023; Pitsia, Biggart, & Karakolidis, 2017).

In the present study, mathematical literacy is conceptualized in accordance with the most recent framework developed for the Programme for International Student Assessment (PISA 2022) (Nolka, 2025; Nolka & Sofianopoulou, 2024a, 2024b). Mathematical literacy is defined as students' capacity to formulate, employ, and interpret mathematics across a variety of contexts, including the ability to reason mathematically and to use mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena (OECD, 2019).

Although mathematics self-efficacy has often been examined as a single, global construct in previous research, the present study adopts a more differentiated approach. Initially conceptualized as a unified measure, mathematics self-efficacy is subsequently disaggregated into four distinct subdimensions: (a) self-efficacy in solving decontextualized mathematical exercises or equations, (b) self-efficacy in solving real-world, contextualized mathematical problems, (c) self-efficacy in competencies associated with mathematical literacy, and (d) self-efficacy in information literacy skills. This analytical distinction enables a more nuanced examination of how different facets of students' confidence relate to mathematical literacy performance.

While prior empirical studies have established a general positive association between mathematics self-efficacy and mathematical literacy, they have largely relied on unidimensional measures of self-efficacy or secondary data from large-scale assessments such as PISA. The present study extends the existing literature by empirically examining multiple, theoretically grounded dimensions of mathematics self-efficacy within an original assessment context. By distinguishing between symbolic, contextualized, literacy-related, and information-based self-efficacy, this study seeks to clarify the specific nature of the relationship between self-efficacy and mathematical literacy and to identify which dimensions of self-efficacy are most strongly associated with students' mathematical literacy performance.

2. RESEARCH

This study involved a sample of 650 students from various regions across Greece who were either in the final stage of the 9th grade or at the beginning of the 10th grade, corresponding to the completion or recent conclusion of compulsory education. Schools were selected based on the degree of urbanization of their location, ensuring representation from large urban centers, small urban centers, and rural areas. This diversity enhances the

generalizability of the findings and provides a representative picture of students completing compulsory education in Greece.

To address the objectives of the research, two instruments were developed and administered: a mathematical literacy test and a questionnaire. The mathematical test consisted of five authentic real-world problems, subdivided into a total of eleven items. These were presented as word problems embedded in realistic contexts, each introduced by a contextual stimulus or narrative. Students' mathematical literacy achievement was operationalized as their performance on this test.

The mathematical tasks were designed to engage students in a range of mathematical processes and content domains. Across the test, students were required to work with proportional, quantitative, spatial, and data-related situations, applying mathematical modeling, reasoning, and interpretation rather than relying solely on routine procedures. The tasks varied in cognitive demand and required students to formulate mathematical relationships, employ appropriate procedures, interpret results within context, and justify their reasoning, in line with contemporary conceptualizations of mathematical literacy.

The second instrument, a questionnaire, consisted of 16 items developed to assess a mathematics self-efficacy index aligned with the PISA framework. The items reflected situations that require students to engage in mathematical reasoning and problem-solving in both abstract and real-world contexts. Responses were recorded on a four-point Likert scale, ranging from "not at all confident" (1) to "very confident" (4). This index captured students' perceived ability to apply mathematical knowledge and skills across a range of cognitively demanding tasks, consistent with the PISA construct of mathematical literacy. The instrument was designed to ensure content validity by incorporating tasks that span both disciplinary (pure mathematics) and contextualized (applied mathematics) domains, thereby providing a reliable measure of students' self-efficacy in line with international large-scale assessment standards.

The mathematics self-efficacy index was initially analyzed as a single composite construct encompassing all 16 items listed in Table 1. For more detailed analysis, the index was further disaggregated into four subcategories:

- Self-efficacy in solving mathematical exercises/equations without a real-world context (S.1–3).
- Self-efficacy in solving real-world problems within a contextual framework (S.4–9).
- Self-efficacy in the abilities of mathematically literate individuals (S.10–14).
- Self-efficacy in information literacy abilities (S.15–16).

Table 1.
Self- efficacy index.

Sentences	How confident are you in your ability to succeed in the following mathematics tasks?
1	To solve an equation like this: $3x+5=17$
2	To solve an equation like this: $6x^2+5=29$
3	To solve an equation like this: $2 \cdot (x+3) = (x+3) \cdot (x-3)$
4	To calculate how much more expensive a computer will be after tax is added.
5	To calculate, based on a table of train schedules, how long it takes to get from one place to another.
6	To calculate how many square meters of tiles are needed to cover a floor.
7	To calculate the weekly consumption of an electronic device.
8	To find the actual distance between two places on a map with a scale of 1:10,000.
9	To calculate the properties of an irregularly shaped object.
10	To derive information from diagrams, graphs or simulations.
11	To interpret the mathematical solutions, you used to answer a problem in everyday life.
12	To recognize the mathematical aspects of a problem from real life.
13	To represent a situation mathematically, using variables, symbols or diagrams.
14	To understand scientific tables presented in an article.
15	To work with mathematical computing systems (e.g. excel, programming software, graphing calculators).
16	To write a code/program on computers.

The study aimed to address the following research questions:

- Is there a statistically significant correlation between mathematical literacy performance and overall self-efficacy in mathematics?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in solving mathematical exercises/equations without a real-world context?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in solving real-world problems?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in the abilities of mathematically literate individuals?
- Is there a statistically significant correlation between mathematical literacy performance and self-efficacy in information literacy abilities?

Ethical considerations were carefully addressed throughout the study. Participation was voluntary, and informed consent was obtained from both students and their legal guardians prior to data collection. Students were informed of the purpose of the study and assured that their responses would remain anonymous and confidential. No personally identifiable information was collected. The research procedures complied with institutional and national ethical guidelines for educational research involving minors.

3. RESULTS

3.1. Overall Mathematics Self-Efficacy

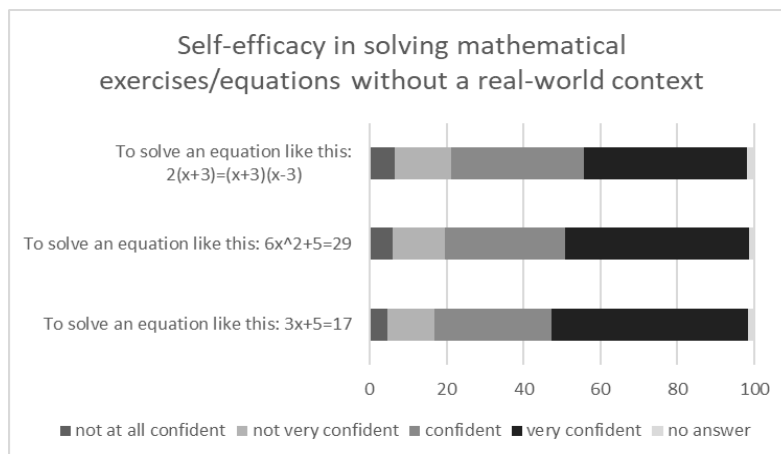
The descriptive findings indicate notable variation in students' self-perceived efficacy across different mathematical domains and task types. Among the items comprising the construct of mathematical self-efficacy, students expressed the highest levels of confidence in their ability to solve algebraic equations. Specifically, over 81% of participants reported feeling confident or very confident in solving a first-degree equation, while 79% indicated similar confidence for solving a second-degree equation. In contrast, the lowest levels of self-efficacy were observed in tasks involving spatial reasoning, particularly the calculation of properties of irregular shapes, with only 21.5% of students expressing confidence.

3.2. Self-Efficacy in Solving Symbolic Mathematical Exercises

Figure 1 illustrates students' self-efficacy regarding their ability to solve symbolic mathematical problems devoid of real-world context. These tasks include first- and second-degree equations and factored expressions, commonly encountered in formal mathematics instruction.

Students reported high levels of confidence in all three items. Over 81% felt confident or very confident in solving a linear equation (e.g., $3x + 5 = 17$), and similarly high percentages were observed for a standard quadratic equation ($6x^2 + 5 = 29$) and a factored expression ($2 \cdot (x + 3) = (x + 3) \cdot (x - 3)$). These results suggest strong procedural fluency and familiarity with symbolic tasks, which are likely reinforced by school-based instructional practices that emphasize symbolic manipulation over applied problem-solving.

Figure 1.
Bar chart of students' self-efficacy (in %) regarding their ability to solve mathematical equations.

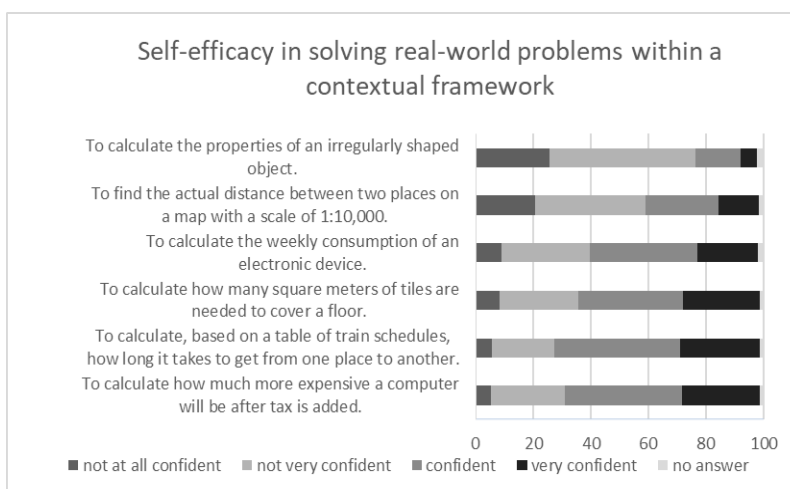


3.3. Self-Efficacy in Solving Real-World Mathematical Problems

Analysis of students' responses to real-world, context-based mathematical tasks revealed significant differences in self-efficacy based on task familiarity and complexity (Figure 2). Students reported greater confidence in routine, everyday applications of mathematics. For example, 71.5% of respondents expressed confidence or strong confidence in calculating the final cost of a computer after tax, and 68% felt similarly about using a train timetable to determine travel time. These results indicate a high level of perceived competence in solving familiar, routine problems grounded in everyday experience.

Conversely, tasks involving spatial or estimation-based reasoning were associated with significantly lower self-efficacy. Only 21.5% of students reported feeling confident in calculating the properties of irregular shapes, and 39.4% felt confident using a map scale to determine actual distances. These findings underscore a broader trend: while students feel confident in routine applications of mathematics, they experience difficulty and reduced self-efficacy in more cognitively demanding and less familiar contexts. The results highlight the importance of designing instructional strategies that build confidence in applying mathematical knowledge across diverse, non-routine, real-world situations, as emphasized in frameworks such as PISA.

Figure 2.
Bar chart of students' self-efficacy (in %) regarding their ability to solve real-world mathematical problems.

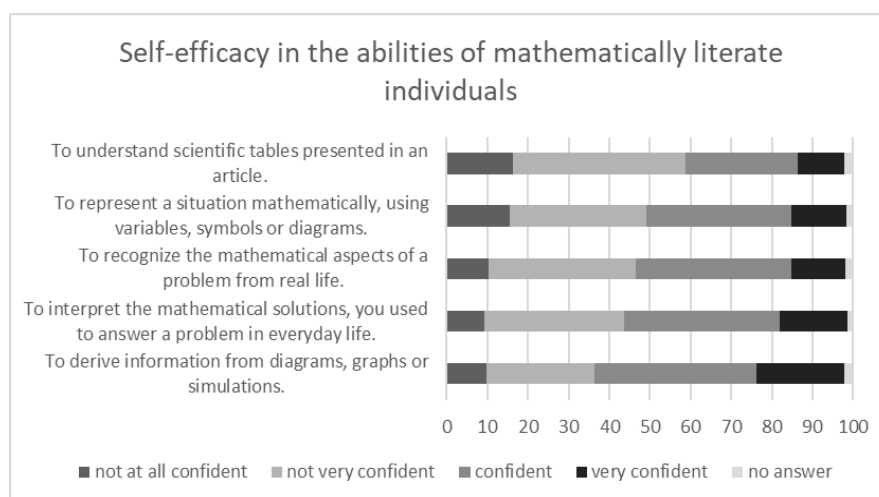


3.4. Self-Efficacy in Core Competencies of Mathematical Literacy

Figure 3 illustrates students' self-efficacy in performing key competencies associated with mathematical literacy, as defined by international assessment frameworks. Among the five competencies measured, students reported the highest confidence in interpreting visual representations (e.g., diagrams, graphs, simulations), with 61.7% feeling confident or very confident. Similarly, 55.1% expressed confidence in interpreting mathematical solutions to real-life problems.

Moderate confidence levels were observed for recognizing mathematical elements in real-world problems and for representing situations mathematically using appropriate symbols or models. Notably, only 39.2% of students reported feeling confident in interpreting scientific tables presented in articles—an ability often required in academic and informational texts. These results suggest a pattern in which students exhibit relatively strong confidence in visually supported reasoning but experience reduced self-efficacy when engaging with more abstract or technical forms of representation. Such disparities highlight the need for educational interventions that develop students' ability to navigate and interpret mathematically dense information across diverse media and contexts.

Figure 3.
Bar chart of students' self-efficacy (in %) regarding their ability to perform key competencies of mathematically literate individuals.



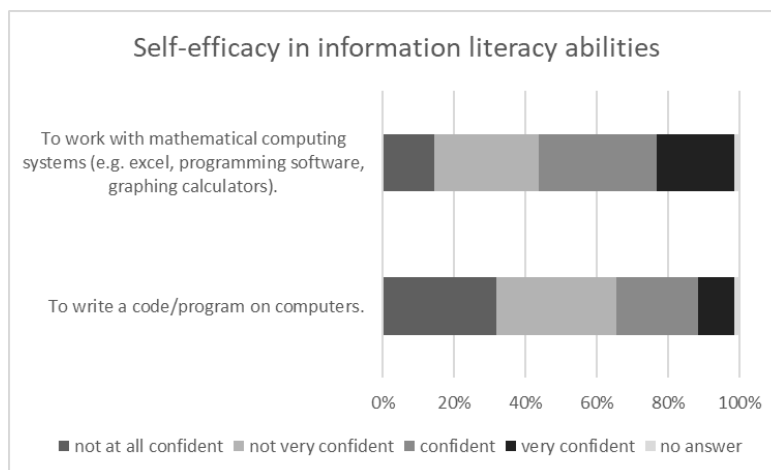
3.5. Self-Efficacy in Information Literacy Abilities

As shown in Figure 4, students' self-efficacy in information literacy abilities varies substantially between different types of digital tasks. A majority of students report low levels of confidence in writing computer code or programs, with 65.7% indicating that they feel “not at all confident” or “not very confident” in this activity. Only one third of the students report feeling confident or very confident in coding-related tasks.

In contrast, students demonstrate comparatively higher self-efficacy in working with mathematical computing systems such as spreadsheets, programming software, or graphing calculators. In this case, 54.9% of students report feeling confident or very confident, suggesting greater familiarity with using existing digital tools than with developing code independently.

This disparity highlights an important distinction between digital tool use and computational production. While students appear reasonably comfortable employing ready-made technological resources to support mathematical tasks, they exhibit considerably lower confidence in activities requiring algorithmic thinking and code creation. These findings underscore the need to strengthen computational and programming-related competencies within mathematics education, particularly as digital and AI-related skills become increasingly central to mathematical literacy.

Figure 4.
Bar chart of students' self-efficacy (in %) regarding their information literacy abilities.



3.6. Reliability and Correlational Analyses

To ensure the internal consistency of the self-efficacy constructs, Cronbach's alpha reliability tests were conducted. As shown in Table 1, all subscales of the self-efficacy in mathematics measure demonstrated acceptable reliability coefficients above the threshold of .700, with the exception of the "information literacy abilities" subscale, which comprised only two items.

Subsequently, Spearman's rho correlation analyses were performed to explore the relationships between students' self-efficacy beliefs and their performance in mathematical literacy. This non-parametric analysis was selected due to the non-normal distribution of the variables.

In the first stage, self-efficacy in mathematics was treated as a single composite variable. A statistically significant positive correlation was identified between this variable and performance in mathematical literacy ($r = .400$, $p < .01$), indicating that students with higher self-efficacy tend to achieve better outcomes.

In the second stage, the composite measure was disaggregated into four subscales to examine domain-specific associations. All four subcomponents were found to correlate positively and significantly with mathematical literacy performance:

- Self-efficacy in solving symbolic exercises/equations: $r = .338$, $p < .01$
- Self-efficacy in solving real-world problems: $r = .379$, $p < .01$
- Self-efficacy in mathematical literacy competencies: $r = .325$, $p < .01$
- Self-efficacy in information literacy abilities: $r = .086$, $p < .01$

Among these, the strongest correlation was observed between mathematical literacy performance and self-efficacy in solving real-world problems. This finding reinforces the importance of cultivating students' confidence and skills in applying mathematics beyond procedural tasks and toward complex, authentic problem contexts

In addition to the self-efficacy findings, overall performance on the mathematical literacy test indicates that students experienced varying levels of success across item types and cognitive demands. On average, students correctly solved fewer than half of the test items, with performance differing notably between multiple-choice and open constructed-response items. Higher success rates were observed on items requiring the application of familiar procedures, whereas lower performance was evident on tasks demanding mathematization, interpretation, and mathematical reasoning. Open constructed-response items, in particular, posed greater difficulty for many students (Nolka, 2025; Nolka & Sofianopoulou, 2025).

4. FUTURE RESEARCH DIRECTIONS

Building on the present findings, future research should aim to expand the scope of inquiry across diverse educational contexts. One promising direction involves broadening the study to include students from different grade levels, particularly earlier or later stages of secondary education, to explore how mathematics self-efficacy evolves over time. Additionally, conducting cross-national comparisons could reveal cultural or curricular influences on students' self-perceptions and performance, contributing to a more nuanced understanding of mathematical literacy across education systems. Another critical avenue for future investigation involves the design and implementation of targeted interventions that strengthen students' self-efficacy in specific subdomains where lower confidence was observed—such as interpreting scientific data or solving real-world problems involving spatial reasoning. Such interventions could combine pedagogical innovation with digital tools to foster both conceptual understanding and confidence. Longitudinal studies evaluating the impact of these interventions on performance and self-efficacy would further enrich the field, offering evidence-based strategies for enhancing students' mathematical resilience and preparedness for data-intensive and AI-mediated futures.

5. CONCLUSION / DISCUSSION

The analysis of the mathematical literacy test revealed that students experienced considerable difficulty in solving realistic problems requiring mathematical literacy skills. Performance was notably lower on tasks involving mathematization, interpretation, and mathematical reasoning, particularly in open constructed-response items. These results suggest that, by the end of compulsory education, students' mathematical literacy competencies are not yet sufficiently developed to support effective engagement with complex, real-world mathematical situations.

Against this backdrop, the findings of the present study provide a robust and empirically substantiated response to the research questions, confirming a statistically significant and positive relationship between students' mathematical literacy performance and their mathematics self-efficacy. This result is consistent with a substantial body of international research highlighting the central role of self-efficacy in predicting mathematical achievement (e.g., Hiller et al., 2022; Kalaycıoğlu, 2015; Karakolidis et al., 2016a, 2016b; Lee, 2009; OECD, 2004, 2013; Pitsia et al., 2017).

Importantly, mathematics self-efficacy was not treated as a single, undifferentiated construct. Instead, the 16-item scale was analytically decomposed into four theoretically grounded dimensions: (a) self-efficacy in solving decontextualized mathematical exercises and equations, (b) self-efficacy in solving real-world, contextualized mathematical problems, (c) self-efficacy in competencies associated with mathematical literacy, and (d) self-efficacy

in information literacy. All four dimensions were found to be positively and significantly associated with mathematical literacy performance, with the strongest relationship observed for self-efficacy in solving real-world mathematical problems. This finding underscores the importance of context-based confidence in supporting students' success in literacy-oriented mathematical tasks.

In contrast to earlier studies that conceptualized mathematics self-efficacy as a global predictor of achievement, the present analysis demonstrates that the strength of its association with mathematical literacy varies meaningfully across different dimensions. The differentiated pattern of relationships observed in this study refines existing evidence by showing that not all forms of mathematical confidence contribute equally to literacy outcomes, thereby offering a more nuanced understanding of how self-efficacy operates within applied mathematical contexts such as those emphasized in PISA.

In sum, the findings of this study highlight the central role of mathematics self-efficacy in shaping students' mathematical literacy at the end of compulsory education. By adopting a multidimensional approach to self-efficacy, the study provides a more refined understanding of how different forms of confidence relate to students' ability to engage with mathematically demanding real-world tasks. The strong association observed between self-efficacy in solving real-world problems and mathematical literacy performance underscores the importance of instructional practices that emphasize contextualized problem-solving and reasoning. Taken together, these results contribute to the existing literature by offering empirical evidence that supports a differentiated conceptualization of mathematics self-efficacy within literacy-oriented assessment frameworks such as PISA.

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Chapter # 14

SUPPORTING SCIENCE TEACHERS TO CULTIVATE EPISTEMIC EMPATHY

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ABSTRACT

Epistemic empathy involves understanding and appreciating others' cognitive and emotional experiences during knowledge construction, communication, and critique. Lacking empathy in science education is a major issue because it causes educators to overlook or undervalue students' unconventional ideas when they stray from established scientific beliefs. Failing to acknowledge the learner's intellectual and emotional struggles can confine student ideas within rigid frameworks, hindering inclusive and equitable learning. To address this challenge, a professional development program was implemented during the 2023/2024 school year for primary and lower secondary school teachers. The program aimed to foster new teaching habits by encouraging the adoption of the Investigative Science Learning Environment (ISLE) approach. The present study sought to connect the development of these professional habits with the growth of epistemic empathy and to assess teachers' awareness of their evolution through their own reflections. Preliminary findings demonstrate that the training framework successfully facilitated the emergence of new teaching habits and enhanced teachers' understanding of epistemic empathy, highlighting the vital role of structured professional development in fostering responsive and student-centered instruction.

Keywords: epistemic empathy, inquiry-based learning, teacher professional development, habits of practices.

1. INTRODUCTION

The concept of Epistemic Empathy pertains to an instructional methodology in which educators are expected to recognize and appreciate the diverse cultural, emotional, and linguistic resources and experiences of students within the domains of science and mathematics education. This approach fosters inquiry and problem-solving skills (Warren et al., 2001).

Responsive teaching constitutes an instructional methodology that promotes student autonomy, guarantees equitable participation among learners, and encourages active engagement in the learning process. This approach underscores the significance of acknowledging and validating students' cognitive and emotional experiences, thereby establishing an inclusive and supportive educational environment that adapts to individual needs and facilitates effective learning outcomes. (Jaber et al., 2018; Jaber, 2021), contributing to the development of a more inclusive and equitable STEM education (Gutiérrez & Rogoff, 2003; Duncan et al., 2023).

The main challenge of responsive teaching is recognizing and valuing students' unconventional insights, even when they deviate from accepted knowledge (Warren & Rosebery, 1996). This process requires that teachers have not only a deep and thorough

understanding of the subject matter, known as strong disciplinary knowledge, but also possess the skills to listen carefully and pay close attention to students. Additionally, teachers must be capable of interpreting students' thinking in a subtle and nuanced way, avoiding the restriction of their ideas within rigid or predefined frameworks. This enables a more comprehensive understanding of student learning and promotes a more supportive educational environment (Hammer & Van Zee, 2006; Jaber et al., 2022a).

In this context, Epistemic Empathy emerges as a vital resource, enabling teachers to go beyond their own perspectives in order to deeply understand students' cognitive and emotional experiences. This understanding fosters authentic learning experiences (Jaber et al., 2021). Epistemic Empathy is essential in this process, as it encompasses more than merely recognizing students' ideas; it involves genuinely comprehending how students interpret and make sense of these ideas, both intellectually and emotionally (Jaber et al., 2018). By cultivating Epistemic Empathy, teachers can create more inclusive and supportive learning environments that nurture students' understanding and personal growth.

Empathy in education is often considered crucial for teacher-student relationships and awareness of students' cultural and social experiences (McAllister & Irvine, 2002; Tettegah & Anderson, 2007; Berkovich, 2020). However, scholarly investigations have neglected its epistemic dimension, specifically how educators demonstrate empathy towards students' cognitive experiences during the formulation and discussion of ideas. Epistemic empathy helps educators appreciate and understand students' reasoning processes, even when these reasoning patterns differ from expected or conventional outcomes. Additionally, it enables educators to recognize and acknowledge the emotional experiences and feelings that students might experience throughout the learning process, fostering a more supportive and empathetic educational environment. (Sikorski, 2016).

This perspective promotes an approach based on students' strengths, treating them as competent thinkers and valuing their contributions (Gutiérrez, 2013). Additionally, epistemic empathy can foster more equitable learning environments by distributing power and authority so that students feel actively involved in constructing knowledge (Segal & Wagaman, 2017; Duncan et al., 2023).

This study seeks to bridge the gap between the Epistemic Empathy framework (Jaber et al., 2022b) and the Development of Habits through Cognitive Apprenticeship (DHAC) framework (Etkina et al., 2017). By aligning these frameworks and adopting the Investigative Science Learning Environment (ISLE) approach, science teachers can shift from traditional knowledge transmission to facilitating learning, recognizing students as capable epistemic agents. Thus, the aim of this study is to evaluate whether our professional development program helps teachers integrate these frameworks into their daily practice effectively. To assess the effectiveness of this intervention, we address the following research questions:

RQ1: How does a training program using the ISLE approach and the DHAC framework help develop new teaching habits that promote epistemic empathy?

RQ2: How aware are teachers of their growth in epistemic empathy through their reflective practices?

2. BACKGROUND

2.1. Responsive Teaching from a Socio-Constructivist Perspective

Rather than solely focusing on the body of canonical knowledge as the ultimate goal, responsive teaching emphasizes starting with students' reasoning and valuing their perspectives, while simultaneously encouraging the development of disciplinary practices involved in learning (Hammer et al., 2012).

The socio-constructivist approach conceptualizes learning as an inherently active and dynamic process, where students are not passive recipients of information but actively engage in constructing their own understanding. In this framework, students are regarded as epistemic agents who take ownership and responsibility for adhering to disciplinary norms and cultivating specific dispositions essential for authentic engagement within their fields of study. This perspective emphasizes the importance of learner agency, collaborative exploration, and contextualized knowledge construction, highlighting the role of social interactions, cultural tools, and prior experiences in shaping learning trajectories (Bruner, 1992; Fler, 2015; Fragkiadaki et al., 2021; Stroupe, 2014).

The learning environment transforms into an active space where knowledge is constructed collaboratively rather than passively received. In this setting, students engage in observation, inquiry, and discovery, actively shaping their understanding (Scardamalia & Bereiter, 2014). Consequently, teaching practices need to evolve to support these dynamic processes, fostering an educational atmosphere that welcomes innovative ideas and student-driven initiatives that arise from active exploration.

Students are seen as bearers of resources, and the teacher's task is to explore and provide space for these resources, supporting students' curiosity and initiative. Disciplinary knowledge is not evaluated based on conformity to a predetermined learning goal but is gradually built starting from students' initial ideas and progressively enriched and supported by the teacher in a responsive manner (Richards & Robertson, 2016). In this approach, teachers act as facilitators rather than mere transmitters of information, encouraging collaborative learning environments where students are active participants in their own learning process. This methodology emphasizes the importance of creating a classroom atmosphere that values students' prior experiences and encourages inquiry, exploration, and critical thinking. The ongoing dialogue between teachers and students allows for flexible teaching strategies tailored to individual needs, fostering deeper understanding and motivation. Such an adaptive approach aligns with contemporary educational theories that advocate for student-centered learning, enabling learners to develop essential skills such as problem-solving, creativity, and self-regulation (Etkina et al., 2006; Hoidn & Reusser, 2020).

Research indicates that responsive teaching methodologies are instrumental in facilitating disciplinary learning by actively engaging students in the construction of knowledge. These approaches emphasize the importance of recognizing the diverse cognitive abilities and contributions of all students, thereby fostering an inclusive learning environment. Central to this pedagogical framework is the acknowledgment that every student has the potential to develop understanding and meaning through interaction and reflective practices. Moreover, responsive teaching assigns significant responsibility to students, empowering them to take ownership of their learning processes. This paradigm shift positions learners at the core of their educational journey, promoting autonomy, motivation, and deeper engagement. Empirical studies and theoretical models, such as those proposed by Scardamalia (2000) and Coffey & Edwards (2016), support the efficacy of responsive teaching in enhancing disciplinary comprehension and fostering critical thinking skills.

2.2. Professional Development of Teachers

Promoting a responsive teaching approach requires teacher training that starts by considering teachers' initial conceptions about teaching scientific disciplines (Robertson & Richards, 2017). Shifting from a traditional knowledge transmission-based pedagogy to an approach based on the active construction of knowledge by students undoubtedly requires a significant shift in perspective, as well as a space for reflection and experimentation that

allows teachers to reflect on their practices and find guidance in experimenting with different approaches (Radoff et al., 2018).

Training pathways should be designed to provide teachers with both conceptual knowledge about innovative teaching and experiential learning paths, where they can test practices that equip them with tools to manage classroom activities (Kennedy, 2006; Thompson et al., 2013; Cartier et al., 2013; O'Connor & Michaels, 2019).

Literature highlights that one of the effective strategies for teacher training involves experiential learning, where teachers are directly involved in scientific inquiry, experiencing the teaching activity as if they were students, while trainers model responsive teaching, encouraging teachers to develop activities based on their own questions and explorations (Atkins & Frank, 2016; Dini et al., 2021; Hammer & Van Zee, 2006). This approach helps teachers recognize and value the emerging scientific thinking of students (Watkins et al., 2017, 2020).

The Development of Habits through Cognitive Apprenticeship (DHAC) framework effectively includes the features mentioned earlier (Etkina et al., 2017; Etkina & Planinsic, 2024). It has been well-tested in both in-service and pre-service teacher training programs focused on incorporating the ISLE (Investigative Science Learning Environment) approach into teaching practices.

In this study, we aimed to theoretically understand the alignment between the Epistemic Empathy teaching approach and the implementation of ISLE. The tasks of teaching (Ball et al., 2008; Etkina et al., 2017) involved when adopting this approach in classrooms are intertwined with the one emphasized in the epistemic empathy framework. Table 1 summarizes the connections between the two frameworks. This connection prompted us to adopt the DHAC framework for the professional development of in-service science teachers, focusing on enhancing their epistemic empathy in relation to the ISLE teaching adoption.

Table 1.
Epistemic empathy and DHAC frameworks alignments.

Epistemic Empathy (Jaber et al., 2022b, Jaber et al., 2023)	Tasks of Teaching adopting the ISLE approach (Etkina et al., 2018; Etkina & Planinsic, 2024)
Noticing and appreciating students' epistemic affect (<i>Recognizing students' intellectual and emotional engagement in learning, such as excitement, frustration, or curiosity</i>)	Recognising student interest and motivation around particular science content and practices
	Engaging all students to express their thinking about key science ideas and encourage students to take responsibility for building their understanding, including knowing how they know
	Developing a climate of respect for scientific inquiry and encourage students' productive deep questions and rich student discourse
	Encouraging broad participation to ensure that no individual students or groups are marginalised in the classroom
	Engaging students in meta-cognition and epistemic cognition
Explaining and justifying students' lines of reasoning (<i>Seeking to understand and clarify why students think in a certain way, even if their reasoning is unconventional or incomplete</i>)	Helping students consider multiple alternative approaches or solutions, including those that could be considered to be incorrect
	Encouraging students to explain features of representations and models (their own and others') and to identify/evaluate both strengths and limitations
	Encouraging students to create, critique, and shift between representations and models with the goal of seeking consistency between and among different representations and models
	Modelling scientific approaches to explanation, argument, and mathematical derivation and explain how they know what they know
	Eliciting student understanding and help them express their thinking via multiple modes of representation

Identifying merits in students' ideas (<i>Finding the productive beginnings in students' thinking, even if it's not fully correct yet</i>)	Employing multiple strategies and tools to make student thinking visible
	Interpreting productive and problematic aspects of student thinking and mathematical reasoning
	Providing students with descriptive feedback
Anticipating students' ideas or feelings (<i>Predicting common misconceptions or struggles students might have and preparing ways to support them</i>)	Anticipating specific student challenges related to constructing scientific concepts, conceptual and quantitative reasoning, experimentation, and the application of science processes
	Addressing learners' actual learning trajectories by building on productive elements and addressing problematic ones
	Designing or selecting and sequencing learning experiences that focus on sense-making around important science concepts and practices, including productive representations, mathematical models, and experiments in science that are connected to students' initial and developing ideas
	Using interpretations of student thinking to support instructional choices both in lesson design and during the course of classroom instruction
Expressing curiosity and interest in students' reasoning (<i>Demonstrating genuine interest in how students think rather than just whether they are "correct"</i>)	Prompting students to collectively generate and validate knowledge with others
	Encouraging broad participation to ensure that no individual students or groups are marginalised in the classroom
	Scaffolding learner flexibility and the development of independence
	Promoting negotiation of shared understanding of forms, concepts, mathematical models, experiments, etc., within the class
Channeling personal experiences to connect with students' intellectual and emotional experiences (<i>Reflecting on one's own learning struggles and using them to empathize with students</i>)	Creating opportunities for students to use science ideas and practices to engage real-world problems in their own contexts
	Helping students make connections between their collective thinking and that of scientists and science communities
	Making explicit distinctions between science practices and those of everyday informal reasoning as well as between scientific expression and everyday language and terms
	Providing opportunities for students to pose their own questions and investigate them experimentally

2.3. The ISLE Approach

We selected the Investigative Science Learning Environment (ISLE), an inquiry-based approach (Etkina et al., 2019; Etkina, 2023) to promote the change in teachers' habits. This framework supports and enhances the cognitive processes emphasized in the experiential learning cycle depicted by Brookes et al. (2020). Given its effectiveness, we recommend adopting ISLE even in early physics education (Bologna, 2023). The ISLE approach actively engages students in scientific practices, encouraging them to think and act like scientists—making observations, developing hypotheses, testing predictions, and refining ideas based on evidence (Etkina et al., 2019; Brookes et al., 2020). It is an intentional and holistic learning environment: intentional in curriculum design, ensuring that what and how students learn are equally important, and holistic in addressing physics as a coherent, comprehensive discipline. The two primary goals of the ISLE approach are: first, to involve students actively in doing physics through a simplified model that mirrors the actual logical progression of physicists' activities (Brookes et al., 2020); and second, to enhance students' well-being during their physics learning journey and motivate them to be engaged in the process (Etkina et al., 2019).

Collaborative learning constitutes a fundamental aspect of this methodology, whereby students engage in group work, discussions, and interactions to enhance comprehension and develop new knowledge.

3. METHODS AND RESULTS

We conducted a comprehensive investigation using a mixed-method research approach, which includes both quantitative surveys and qualitative interviews.

We engaged a group of 75 teachers from primary and low secondary education in a training program designed to familiarize them with the ISLE approach. The course was organized into three modules: a starting module, an intermediate module, and an advanced module, with each one lasting four hours. Then, teachers could adopt the ISLE activities in their classes, sometimes being tutored or coached by a trainer researcher. In total, approximately 80 classes participated in these activities- half tutored and half coached- resulting in 229 hours of teaching practice focused on ISLE.

We followed a structured procedure to evaluate the impact of the training program and its effect on teachers' development of new habits. We created a comprehensive survey aimed at capturing various aspects of the training program.

This included questions on teachers' self-assessment of new habits, their engagement throughout the training, and perceived changes in their teaching practices. We identified a representative sample of teachers who participated in the training program (54 participants over 75). This ensured that our results would reflect a broad range of experiences and perspectives. The survey was distributed to the selected teachers through an online platform. We encouraged participation by emphasizing the importance of their feedback in shaping our research project. Once the responses were collected, we conducted a thorough analysis to identify trends, patterns, and correlations. This included quantitative analysis of scaled questions and qualitative analysis of open-ended responses. The study was conducted using AILYZE software (www.ailyze.com, 2025, AILYZE Inc.), employing an inductive approach to identify themes across the entire dataset. It was used not as a final analytical authority but as a tool for initial inductive identification of themes. This software enabled rapid processing of large-scale qualitative data, identifying complex patterns and linguistic cues that manual coding might overlook. This method overcomes the limitations of traditional coding by capturing broader themes and complex discussions, ensuring consistent detection and faster analysis. After generating initial AI outputs, we manually cross-checked them against the raw data to assess thematic saturation and resolve discrepancies. This approach maintained the "inductive approach" in interpretive accuracy, adding a deeper coding layer that linked teacher reflections with pedagogical theory.

Finally, we synthesized the data into a report that outlines the effectiveness of the training program in facilitating new habits among teachers. This procedure ensures a systematic approach to evaluating the program and provides valuable insights into its effectiveness, answering the two research questions.

The main results are summarized in Table 2, which provides a comprehensive overview of the findings. This table illustrates how teachers' responses highlight the key features and components involved in the activation process of Epistemic Empathy, offering valuable insights into the mechanisms and indicators associated with this cognitive and emotional skill.

Table 2.
Alignment of the results with the Epistemic Empathy framework (Jaber et al., 2023).

Epistemic Empathy (Jaber et al., 2023)	Synthesis Results
Noticing and appreciating students' epistemic affect (<i>Recognizing students' intellectual and emotional engagement in learning, such as excitement, frustration, or curiosity</i>)	• Active involvement over passive learning. • Hands-on engagement. • Allowing students to conduct observations, formulate hypotheses, and perform experiments. • Fosters a deeper understanding of scientific concepts. • Enhances student motivation and engagement. • When students engage with real-world phenomena, their curiosity is ignited, making their learning experiences more relevant and impactful.
Explaining and justifying students' lines of reasoning (<i>Seeking to understand and clarify why students think in a certain way, even if their reasoning is unconventional or incomplete</i>)	• Breaking down intricate scientific principles into digestible segments. • This process enhances students' grasp of foundational ideas. • The demystification process not only aids retention. • It also equips students with essential critical thinking skills. • Students articulate their thought processes.
Identifying merits in students' ideas (<i>Finding the productive beginnings in students' thinking, even if it's not fully correct yet</i>)	• Students with diverse learning abilities, including those with disabilities, benefit immensely from a learning framework that encourages them to express their understanding and creativity • Empowerment fosters a sense of belonging in their contributions • Cultivating a supportive learning environment
Anticipating students' ideas or feelings (<i>Predicting common misconceptions or struggles students might have and preparing ways to support them</i>)	• The ISLE framework's ability to simplify complex topics is noteworthy • Helped demystify challenging content, allowing all students to engage meaningfully with the material • Active participation • Recognizing and accommodating the varied needs of all students.
Expressing curiosity and interest in students' reasoning (<i>Demonstrating genuine interest in how students think rather than just whether they are 'correct'</i>)	• Placing students at the center of the learning process nurtures observation, reasoning, and reflective skills that are critical for engaged learning • Students become active participants in their learning journeys, which fosters a sense of ownership • This intrinsic motivation becomes a driving force, allowing learners to develop a lifelong curiosity about scientific inquiry and the world around them
Channeling personal experiences to connect with students' intellectual and emotional experiences (<i>Reflecting on one's own learning struggles and using them to empathize with students</i>)	• Making science accessible to everyone • Science education can be made accessible • Students engage with real-world phenomena • Making their learning experiences more relevant and impactful

4. DISCUSSION AND CONCLUSION

The initial insights from the study reveal notable and substantive changes in teaching practices, providing clear evidence for how the training program addressed the research goals. Regarding RQ1, the findings demonstrate that the professional development program, grounded in the Investigative Science Learning Environment (ISLE) approach and the Development of Habits through Cognitive Apprenticeship (DHAC) framework, effectively facilitated the emergence of new professional habits. A primary focus has been fostering students' conceptual development through observation-based learning strategies, with 68.1% of respondents emphasizing the importance of this approach. Teachers are increasingly encouraging students to build understanding from direct observations, which supports deeper cognitive engagement (Talavera-Mendoza et al, 2024). Additionally, there is a significant emphasis on promoting the formulation of hypotheses and employing hypothetical-deductive reasoning methods; again, 68.1% of educators reported prioritizing these practices. This reflects a shift toward encouraging scientific thinking and analytical reasoning in classroom settings (Arifin et al., 2025).

These shifts align closely with the concept of epistemic empathy, which involves recognizing and responding to students' intellectual and emotional states during learning—such as feelings of excitement, frustration, or curiosity (Jaber et al., 2024). Supporting this, a notable 57.4% of teachers focus on nurturing students' intuitive ideas, demonstrating a commitment to understanding and engaging with students' reasoning processes—even when their ideas are preliminary or incomplete. This finding is critical to resolving RQ2, as it demonstrates that teachers are developing a conscious awareness of their professional evolution as facilitators who value students as competent epistemic agents. This approach addresses the importance of exploring the reasoning behind students' thoughts, helping them refine their ideas and justify their thinking rather than dismissing unconventional or initial ideas outright.

A further significant change related to RQ1 pertains to the design of experiments aimed at testing hypotheses, with 63.8% of educators identifying this as a crucial practice. This indicates a pedagogical shift toward leveraging students' initial, sometimes imperfect, ideas as valuable starting points for scientific inquiry, thereby fostering a classroom environment where inquiry and exploration are actively encouraged. However, regarding the depth of teacher awareness (RQ2), the data uncovered a "predictive gap": only 10.6% of teachers reported an increased focus on anticipating students' difficulties.

The ISLE (Investigative Science Learning Environment) approach itself promotes a responsive teaching style. However, the findings suggest that there are still gaps in teachers' ability to anticipate students' struggles and misconceptions. Addressing this gap is essential; without proactive epistemic empathy, teachers may inadvertently maintain the rigid, predefined frameworks that marginalize diverse student perspectives and create barriers to inclusive learning. These results suggest that the training program has successfully fostered new teaching habits (RQ1) and significantly increased teachers' awareness of their own epistemic empathy (RQ2), ultimately enriching their capacity to support student learning in nuanced, responsive, and equitable ways.

ISLE training has notably improved teachers' capacity to observe, validate, and build upon students' reasoning processes. Nonetheless, there remains room to enhance their ability to predict and respond to students' difficulties and harness their intuitive ideas more effectively, which could further improve targeted support. Overall, these preliminary results suggest that participation in the training program has successfully fostered the development of new teaching habits and significantly increased teachers' epistemic empathy, ultimately enriching their capacity to support student learning in more nuanced and responsive ways.

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Chapter # 15

INTEGRATING ADVANCED TECHNOLOGY FOR PEDAGOGICAL ENHANCEMENT IN GRADE 10 ACCOUNTING INSTRUCTION: A SOUTH AFRICAN VIEWPOINT

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ABSTRACT

The study investigated the integration of technology into Grade 10 accounting instruction, examining how teachers adapted their methodologies to incorporate various technological tools, such as online platforms and interactive software, following the COVID-19 pandemic. A qualitative research approach was employed. The study adopted a constructivist learning theory. A purposive sample of 15 accounting teachers from five schools in the OR Tambo Coastal region was utilised. Data were collected through in-depth interviews. The data was analysed using thematic analysis. The study concluded that while technology integration offered significant benefits for educational outcomes in accounting, it also revealed challenges that require comprehensive training programs and strategic investments in resources. Future research could investigate the long-term effects of technology integration on learner performance and identify effective practices for teacher professional development. The study recommended ongoing professional development programs tailored for accounting teachers, prioritising resource allocation for technology access, and establishing collaborative learning communities among teachers. Additionally, training programs were developed to enhance learners' technological skills. Updating the curriculum to emphasise digital literacy and creating robust support systems for technical issues were essential.

Keywords: technology integration, blended learning, teacher training, learner engagement, accounting education.

1. INTRODUCTION

The integration of technology in teaching Grade 10 accounting has gained significant importance, especially in the wake of the COVID-19 pandemic, which necessitated a rapid shift from traditional classroom settings to online learning environments (Agustina & Setiawan, 2020; Ahshan, 2021). Accounting is an essential subject that equips learners with foundational skills and knowledge critical for navigating the business world, including understanding financial transactions, preparing financial statements, and applying accounting principles. The pandemic's disruption accelerated the adoption of technological tools by teachers to maintain educational standards and engage learners effectively in remote or hybrid settings (Ahshan, 2021; Haleem, Javaid, Qadri, & Suman, 2022). Before the pandemic, accounting education largely depended on face-to-face instruction and manual methods of bookkeeping and analysis. However, with the sudden need for remote learning, teachers turned to a variety of online platforms, interactive software, and digital resources to support teaching and learning processes. Tools such as spreadsheet software (e.g., Microsoft Excel), accounting software packages, and virtual classrooms became integral to lessons,

enabling learners to practice real-world accounting skills in a virtual format (Haleem et al., 2022; Technology-Integrated Lesson Plan, 2025). For instance, teachers introduced learners to spreadsheet functions to organise, analyse, and present financial data, therefore reinforcing both theoretical concepts and practical competencies in a digital context. Incorporation of technology extends beyond mere replacement of physical classrooms with online platforms; it transforms pedagogical strategies to enhance learning. Teachers employ varied approaches, including interactive lectures supplemented by digital demonstrations, group collaborations through virtual meeting tools, and hands-on exercises using accounting software, fostering an active and engaging learning environment despite physical separation (Teacher's Guide for Grade 10 Accounting, 2025). Technology also enables timely feedback and assessment, allowing teachers to track progress and address learning gaps more efficiently.

The following research question guided the study:

1. What teaching approaches were employed by teachers to incorporate technology in instructing Grade 10 Accounting learners?

2. BACKGROUND OF THE STUDY

The integration of advanced technology in teaching Grade 10 accounting has become increasingly critical within the South African education system, especially following the disruptions caused by the COVID-19 pandemic (Skhephe, 2022). Traditionally, accounting education relied heavily on face-to-face instruction and manual bookkeeping methods, but the rapid shift to remote and blended learning environments necessitated the adoption of various technological tools (Sangster, Stoner, & Flood, 2020). These include online platforms, interactive software, spreadsheet programs such as Microsoft Excel, and accounting applications that enable learners to engage with real-world accounting tasks digitally (Agustina & Setiawan, 2020; Haleem et al., 2022). In South Africa, particularly in regions such as the OR Tambo Coastal area, teachers have adapted their pedagogical approaches to incorporate technology, fostering more active, learner-centred environments aligned with constructivist theory. Such strategies promote critical thinking and enhance learner engagement, even in the face of physical separation (Banihashem et al., 2022; Teacher's Guide for Grade 10 Accounting, 2025).

However, the integration process is challenged by systemic barriers, including inadequate teacher training, limited access to reliable technological resources, and disparities in learners' technological proficiency and access (Msomi et al., 2025; Starkey, 2020). Moreover, the accounting curriculum has expanded to include complex topics that require both conceptual and technological mastery, adding cognitive demands on learners (Msomi et al., 2025). Despite obstacles, effective technology integration supports continuity of instruction and enriches educational experiences, equipping learners with the essential digital literacy skills required for the evolving accounting profession, which increasingly relies on automated systems and data analytics (Agustina & Setiawan, 2020; Haleem et al., 2022). The study, therefore, examines how Grade 10 accounting teachers in the OR Tambo Coastal region pedagogically interpret and utilise advanced technology to enhance teaching and learning, aiming to identify effective strategies and address existing challenges within the South African context.

3. LITERATURE REVIEW

Recent studies have highlighted the transformative impact of technology in education, particularly in enhancing learner engagement and critical thinking, while improving access to learning materials (Okolie et al., 2022). Innovative methods such as project-based learning and flipped classrooms have gained traction, promoting active learner participation (Nkomo, Daniel, & Butson, 2021). However, many teachers continue to rely on traditional teaching methods, indicating a need for effective training programs to facilitate the integration of technology in a meaningful way. In Grade 10 accounting, the use of technology has become increasingly important since the COVID-19 pandemic, yet its implementation remains inconsistent (Sangster, Stoner, & Flood, 2020). Teachers often struggle with modern technology despite acknowledging its significance for future job preparation. Addressing challenges such as technical issues, limited resources, and gaps in learner technical skills is crucial for successful integration (Onyema, 2020). The existing literature offers a comprehensive examination of the benefits and challenges of integrating technology in Grade 10 accounting education, highlighting the issues faced by both teachers and learners. However, there is a notable gap in studies that specifically examine the interconnected effects of teacher preparedness, learner digital literacy, and infrastructural disparities within the South African context, particularly in the post-COVID-19 era (Sangster, Stoner, & Flood, 2020). Furthermore, while prior research identifies challenges and suggests broad strategies, few studies offer detailed, context-specific interventions tailored to Grade 10 accounting teachers and learners that address these multifaceted barriers holistically (Onyema, 2020). The study aims to fill these gaps by investigating how targeted professional development and resource support could enhance technology use and learning outcomes in this area.

3.1. Challenges Faced by Teachers in Using Advanced Technology to Teach Grade 10 Accounting

Research underlined the transformative role of technology in education, emphasising its capacity to enhance learner engagement, foster critical thinking, and improve access to diverse learning resources (Nkomo et al., 2021). Technological tools create dynamic learning environments that move beyond passive reception of information, encouraging learners to actively participate and apply their knowledge (Laine & Nygren, 2016). Among the innovative instructional methods gaining traction are project-based learning and flipped classrooms, which rely heavily on technology to facilitate active learner participation and deeper learning (Rothwell, 2020). Project-based learning enables learners to explore real-world problems, often utilising digital tools to research, collaborate, and present their findings, thereby connecting theory to practice. Flipped classrooms invert traditional teaching by delivering instructional content online outside of class, freeing up in-person time for interactive problem-solving and discussion, which enhances learner engagement and mastery of material (Heiss & Oxley, 2021). Despite these promising developments, many teachers continue to rely on traditional teaching approaches that may not fully leverage the potential of technology to transform learning. This adherence highlights a pressing need for effective and ongoing training programs aimed at empowering teachers with the necessary skills and confidence to integrate technology meaningfully into their pedagogy (Fobert, 2024). Technology integration is not merely about using digital devices; it requires a pedagogical shift that aligns teaching methods with modern technological affordances to support varied learning styles and promote critical competencies in learners (Thelma, Sain, Mpolomoka, Akpan, & Davy, 2024).

The pandemic accelerated the shift from conventional classrooms to virtual and blended learning environments, necessitating the adoption of various technological tools to maintain instructional continuity and quality (Anthony Jnr & Noel, 2021). However, the implementation of technology in Grade 10 accounting classrooms remains inconsistent. While some schools and teachers successfully incorporate digital resources such as accounting software, spreadsheets, and online assessment platforms, others struggle due to limited access or insufficient technical expertise. Teachers often face several barriers in utilising modern technology effectively. For example, many teachers confront challenges such as a lack of access to up-to-date devices, unreliable internet connectivity, and insufficient training on how to integrate these tools within accounting curricula to enhance learning outcomes (Nkomo et al., 2021; Insights from a South African University of Technology, 2025).

Moreover, technical issues during lessons, such as software malfunctions or platform usability problems, could disrupt teaching and diminish the benefits technology could offer (Reich, 2020). The challenges underline a critical need for robust teacher training and ongoing technical support, focusing not only on familiarisation with technological tools but also on pedagogical strategies for their effective use. Inequitable access to technology creates a digital divide that affects both teachers' capacity to deliver instruction and learners' opportunities to learn effectively with digital tools. This issue affects the consistency of technology integration in Grade 10 accounting education, leading to uneven learner experiences and potential gaps in acquiring the crucial digital literacy and accounting skills necessary for future academic and career success (Eloff, 2016). Addressing these challenges requires a multifaceted intervention. Professional development programs tailored specifically for accounting teachers may incorporate hands-on training in relevant software, digital pedagogies, and troubleshooting common technical issues (Nkomo & Ndovela, 2025). Moreover, schools and educational authorities may invest in infrastructure improvements, such as reliable internet access and updated hardware, to support seamless technology use. Encouraging collaboration among teachers through professional learning communities could also facilitate the sharing of best practices and innovative strategies, fostering a culture of continuous improvement in technology integration (Antinluoma, Ilomäki, & Toom, 2021).

3.2. Challenges Faced by Grade 10 Learners in Learning Accounting using Advanced Technology

Grade 10 learners encounter several significant challenges when utilising advanced technology to learn accounting, which could substantially hinder their acquisition and understanding of key accounting concepts (Sangster, Stoner, & Flood, 2020).

3.2.1. Skills Deficit and Technical Complexity

One of the foremost issues is the gap in technical skills among learners. Many learners lack the necessary competencies to navigate and operate advanced accounting software, which is often complex and requires familiarity with various digital functions (Lajnef, 2025). The skills deficit frequently leads to frustration, anxiety, and disengagement, as learners struggle to keep pace with instructional demands that assume a higher baseline of technological proficiency. In many schools, particularly in rural or under-resourced areas, learners lack consistent access to computers, tablets, or reliable internet connections, which are essential for utilising sophisticated digital accounting tools (Msomi et al., 2025). The complexity of advanced accounting software itself presents another substantial barrier. For beginners, the steep learning curve required to understand features, menus, formulas, and functions could be overwhelming (Rothwell, 2020). Many learners encounter challenges in

mastering the software's interface and applying it to theoretical accounting principles, which may lead to decreased participation and lower motivation. This difficulty is compounded in cases where learners lack sufficient guided practice or where lesson pacing does not adequately account for the time required to master technological tools. Without appropriate scaffolding, learners may struggle to connect practical software tasks with underlying accounting concepts, which could negatively affect knowledge retention and application (Reiser, 2018).

3.2.2. Learner Attitudes and Anxiety

Learners' attitudes toward technology could also play a critical role in these challenges. Some learners may resist using technology either due to discomfort with change or a preference for traditional, pen-and-paper methods of learning. This resistance could stem from unfamiliarity with digital devices, fear of making errors in software, or an attachment to conventional teaching styles that they perceive as more straightforward or effective (Nkomo et al., 2021). Such attitudes diminish enthusiasm and openness to technology-rich learning environments, creating further hurdles for teachers seeking to integrate digital tools effectively. Furthermore, learners who experience anxiety or self-doubt when confronted with technology are less likely to engage fully or experiment with new software, limiting their opportunities to build proficiency.

3.2.3. Teacher Support and Preparedness

Moreover, a lack of adequate teacher support significantly exacerbates these challenges. Many teachers themselves feel insufficiently prepared or confident in their own ICT skills to effectively guide learners through the use of advanced accounting software (Msomi et al., 2025). Insufficient professional development and access to ongoing training leave teachers struggling to troubleshoot technological issues, deliver lessons that effectively incorporate digital tools, and provide timely assistance to learners encountering difficulties (Ferri, Grifoni, & Guzzo, 2020). This lack of support could result in ineffective technology integration, with teachers reverting to traditional methods to compensate, which further limits learners' exposure to technology-enhanced accounting education. Without teacher confidence and competence in technology, the potential benefits of digital learning tools remain underutilised, and learners' learning is compromised (Mhlongo, Mbatha, Ramatsetse, & Dlamini, 2023).

3.2.4. Infrastructure and Resource Scarcity

Many schools lack sufficient technological infrastructure, including up-to-date computers, software licenses, and stable internet connectivity. Overcrowded classrooms and a high learner-to-device ratio mean learners may share limited technology resources, reducing the time for individual practice that is essential for mastering complex software (Msomi et al., 2025). The COVID-19 pandemic has further highlighted these disparities, as remote and hybrid learning models require a greater reliance on technology, thereby amplifying inequities where inadequate infrastructure exists. This scarcity impedes regular and meaningful engagement with technology, which is crucial for learners to develop confidence and competence in digital accounting tools (Lajnef, 2025).

3.2.5. Language and Curriculum Complexities

Language and curriculum complexities interplay closely with technological challenges. For instance, accounting terminology and instructions are often delivered in English, which may not be the first language for many learners, complicating both comprehension and use

of software interfaces (Msomi et al., 2025). The technical language used in accounting software and educational materials could be daunting, making it difficult for learners to fully grasp instructional content or navigate digital platforms effectively (Lajnef, 2025). Additionally, the curriculum has expanded to include more sophisticated topics, such as auditing, internal controls, and financial analysis, which require a deeper conceptual understanding complemented by technological proficiency. Without adequate scaffolding, learners could feel overwhelmed by the simultaneous demands of mastering both complex content and technology, increasing cognitive load and reducing learning efficiency (Sweller, 2020).

3.2.6. Comprehensive Strategies for Addressing Learner Challenges

Addressing these multifaceted challenges requires a comprehensive and strategic approach. First, enhanced and continuous training programs for both learners and teachers are crucial (Petar, 2024). For learners, targeted digital literacy programs that focus on basic to intermediate ICT skills and software-specific training may help bridge the technical skills gap and reduce frustration (Ben Youssef, Dahmani, & Ragni, 2022). These programs could use incremental skill-building exercises that gradually introduce learners to software functionalities in manageable steps. For teachers, professional development could emphasise technological pedagogical content knowledge, combining subject mastery with effective technology use and ongoing technical support to build confidence and competence (Msomi et al., 2025; Nkomo et al., 2021). This empowerment enables teachers to confidently implement technology-enhanced accounting instruction, troubleshoot technical issues promptly, and provide effective support to learners.

4. THEORETICAL FRAMEWORK

The study adopted constructivist learning theory, which posits that learners learn most effectively through active engagement and personal experience (Banihashem et al., 2022). Within the framework, learners were encouraged to utilise technology to understand and apply accounting concepts rather than passively receive information. Tools such as interactive simulations and accounting software facilitate practice in real-world scenarios. Learner-centred pedagogy emphasises active learner participation, enabling teachers to create collaborative environments where learners may ask questions and solve problems together (Banihashem et al., 2022). Techniques such as flipped classrooms and project-based learning further promote engagement and critical thinking. To effectively integrate technology, teachers could employ models that evaluate technology use in lessons. Collaborative learning through online tools enhances understanding while developing essential workplace skills. Addressing challenges such as technical issues and inadequate teacher training is crucial for the successful implementation of this initiative.

5. METHODS

5.1. Research Approach

The study, titled "Pedagogical Interpretation in Teaching Grade 10 Accounting Using Advanced Technology," employed a qualitative research approach to investigate how teachers interpret and utilise advanced technology in their instruction (Chong & Reinders, 2020). A case study design focuses on specific teachers and their methods, allowing for an in-depth examination of technology integration in accounting lessons. An interpretive approach was used to understand the meanings attributed to experiences with technology,

understanding how both teachers and learners engaged with advanced tools in accounting education. Ethical guidelines were strictly adhered to, including obtaining informed consent from participants and ensuring confidentiality. The study acknowledges potential limitations, such as a small participant pool that may affect generalizability (Chong & Reinders, 2020). Nevertheless, the approach aims to provide valuable insights into teaching practices in Grade 10 accounting by utilising advanced technology.

5.2. Population and Sampling

For the qualitative study on integrating advanced technology in teaching Grade 10 accounting, the population consisted of 15 accounting teachers from various schools within the OR Tambo Coastal region that had incorporated technology into their lessons (Zamokuhle, Zikhona, & Ngqunguza, 2025). The group was crucial as they directly experienced the impacts of technology on teaching and learning processes. The sample size was limited to facilitate in-depth insights into their experiences, providing a diverse range of perspectives on how they utilised technology in their classrooms. The sample size was suitable for qualitative research, emphasising a deep understanding of experiences and opinions. By gathering data completely from teachers, the study uncovered effective strategies for technology use in accounting education while identifying the challenges they encountered (Handoyo, 2024). The focused approach enhanced teaching methodologies, ensuring that teachers were equipped to prepare learners with the necessary skills for careers in accounting.

5.3. Data Collection

Interviews were employed as the primary data collection method in the study, specifically through semi-structured interviews with Grade 10 accounting teachers (Mkhize, Mtshali, & Ntombela, 2023). The approach involved posing open-ended questions that enabled teachers to articulate their thoughts, experiences, challenges, and strategies regarding the use of technology in their instruction (Braun & Clarke, 2021). Such a method facilitated a deeper understanding of how teachers integrate technology into their teaching practices and the various factors influencing their experiences. Interviews lasted between 30 and 45 minutes, allowing sufficient time to explore participants' experiences in depth. Data saturation was determined when no new themes or insights emerged from successive interviews, indicating sufficient coverage of the research topics.

5.4. Data Analysis

The study employed thematic analysis to identify patterns and themes within the collected data (Braun & Clarke, 2021). The process involved systematically organising information obtained from interviews, focus groups, observations, and documents to highlight key insights regarding the use of technology in the teaching of Grade 10 accounting (Mkhize, Mtshali, & Ntombela, 2023). By analysing the data thematically, the research aimed to uncover significant trends and understand how technology is integrated into instructional practices.

6. FINDINGS

Figure 1.
Traditional vs. Modern Pedagogies in Accounting Education.

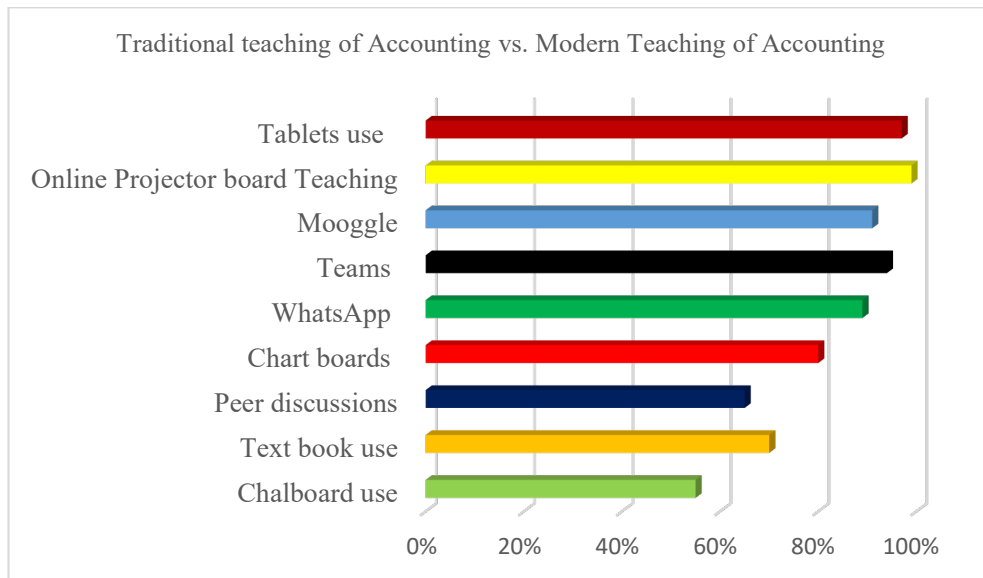


Figure 1 shows usage rates: chalkboards 55%, textbooks 70%, peer discussions 65%, chart boards 80%, WhatsApp 89%, Teams 94%, Mooggle 91%, tablets 97%, online projectors 99%.

Figure 2.
Pedagogical Challenges in Accounting.

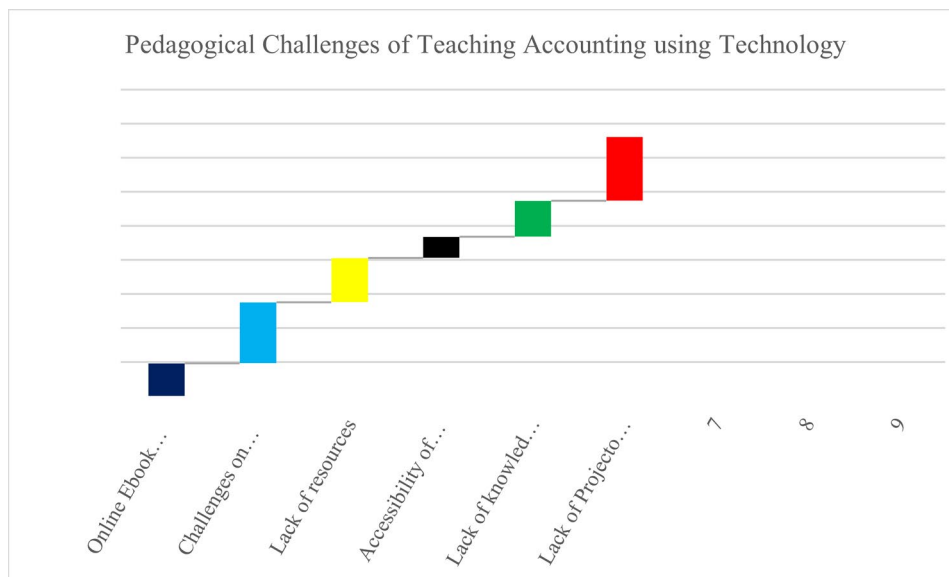


Figure 2 illustrates the challenges of pedagogy in teaching accounting with technology, highlighting issues such as teacher preparedness, resource limitations, and varying learner readiness that hinder effective integration of technology.

Figure 3.
Effective Accounting Teaching Strategies.

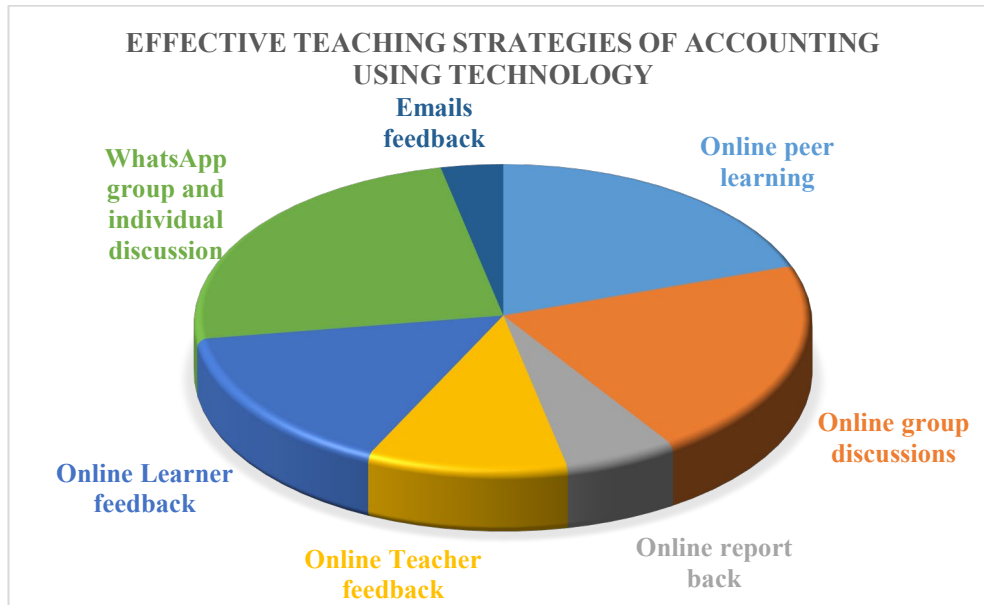


Figure 3 shows effective accounting teaching strategies: Email feedback 13%, WhatsApp discussions 94%, online learner feedback 60%, teacher feedback 41%, report back 23%, group discussions 82%, and peer learning 77%.

7. DISCUSSIONS

The data revealed varying degrees of technology integration in accounting education, with significant preferences for digital tools (Onyema, 2020). Online Projector Board Teaching was the most utilised method at 99%, followed by Tablets at 97% and Microsoft Teams at 94% (Das, 2024). However, traditional methods such as chalkboards (55%) and textbooks (70%) remained common, indicating resistance to digital transformation (Oyinloye, 2022). The findings highlighted critical gaps in resources, teacher preparedness, and technological accessibility (Starkey, 2020). 94% of schools lacked projector boards, limiting teachers' ability to present complex concepts effectively. Approximately 53% of teachers reported insufficient knowledge of online teaching methodologies, emphasising the need for professional development (Sangster, Stoner, & Flood, 2020). Connectivity issues further complicated the landscape, with 90% of teachers experiencing online connectivity challenges. Effective teaching strategies emerged, with WhatsApp groups and individual discussions favoured by 94% of participants (Nkomo, Daniel, & Butson, 2021). The high WhatsApp adoption rate in low-resource settings suggests that appropriate technology strategies could prioritise accessibility, low data consumption, and usability on widely available mobile devices. WhatsApp's popularity in regions such as Africa, where it accounts

for a significant portion of mobile internet use, highlights how technologies that operate efficiently with limited infrastructure and offer offline-friendly features could be highly effective. This suggests that digital education or communication interventions in low-resource contexts may leverage inexpensive, familiar, and easy-to-use platforms, such as WhatsApp, to maximise reach and engagement. The platform's success also demonstrates the value of integrating multimedia communication and facilitating quick, real-time interactions in such settings to support effective learning and collaboration.

The findings study highlighted the constructivist learning theory's emphasis on active learner engagement and meaning-making through technology-enhanced pedagogies. For example, the integration of interactive platforms such as Microsoft Teams and accounting software aligns with constructivist principles by enabling learners to construct knowledge through collaboration and hands-on experience (Banihashem et al., 2022). The prevalence of digital tools, such as online projectors and tablets, supports the shift towards learner-centred instruction, which facilitates critical thinking and the practical application of accounting concepts, extending beyond traditional rote methods. However, the challenges related to teacher preparedness and resource limitations highlight the gap between theoretical ideals and practical realities. Despite constructivism's support for rich, technology-mediated learning environments, many teachers reported insufficient training and infrastructural support, which restricted the full realisation of these pedagogical innovations. This inconsistency highlights the need for further support of teacher development programs, enabling educators to confidently translate constructivist approaches into technologically mediated contexts (Fobert, 2024). Furthermore, the digital divide and learners varied technological competencies emphasise the importance of adaptive pedagogical strategies that accommodate diverse learner needs, a key principle of constructivist theory. Employing differentiated instruction and support may help mitigate cognitive overload, enabling learners to effectively connect complex accounting principles with technological tools (Sweller, 2020; Banihashem et al., 2022). The study thus confirms and extends constructivist understandings by illustrating the critical interplay between pedagogical theory, technological access, and educational equity in the South African Grade 10 accounting context.

The prominent use of digital tools such as Microsoft Teams, tablets, and online projectors reflects a shift towards learner-centred pedagogies, consistent with constructivist principles that prioritise collaboration, interaction, and hands-on activities. These tools enable learners to engage meaningfully with accounting concepts through real-world simulations and problem-solving exercises, aligning with research encouraging the integration of information technology and curriculum content as a dynamic, inseparable educational process (Zhou, 2017). The study highlights that technology-supported instruction facilitates scaffolding, allowing teachers to tailor support to learners' varying levels of digital literacy and accounting knowledge. This scaffolding is crucial in managing the cognitive load introduced by simultaneously mastering complex accounting principles and advanced technological tools (Sweller, 2020). The findings align with prior research, which has consistently demonstrated the effectiveness of differentiated instruction and project-based learning within technologically enriched environments in promoting deeper learning and learner autonomy (Antonietti, 2025; Rothwell, 2020).

However, the results also underline persistent challenges that impede pedagogical transformation, such as inadequate teacher training and uneven access to resources. These systemic barriers create a tension between the ideals of constructivist pedagogy and practical realities in under-resourced contexts (Msomi et al., 2025; Fobert, 2024). The reported lack of confidence and technical know-how among some teachers highlights the critical need for comprehensive professional development programs that integrate technological,

pedagogical, and content knowledge (TPACK) to bridge this gap (Nkomo et al., 2021). This aligns with the literature, which emphasises that the effective integration of technology requires not only device availability but also pedagogical readiness and ongoing technical support (Anthony Jr. & Noel, 2021). In applying these findings, schools and educational policymakers could consider fostering collaborative professional learning communities where teachers share best practices and co-develop technology-enhanced instructional strategies. Moreover, addressing infrastructural inequities through targeted investments may help minimise the digital divide, enabling a more equitable learning experience, an imperative echoed throughout South African education research (Eloff, 2016; Starkey, 2020). Comparatively, while some schools demonstrate high levels of technology adoption with active learner participation, others remain reliant on traditional approaches, revealing variability reminiscent of findings in other regions facing similar resource disparities (Onyema, 2020; Nkomo et al., 2021). This variability suggests opportunities for further comparative research to identify contextual factors that facilitate or hinder the successful integration of technology in accounting education.

8. CONCLUSION

The qualitative study has understood the transformative impact and critical importance of integrating advanced technology into Grade 10 accounting education within the South African context, particularly in the OR Tambo Coastal region. The research revealed that teachers have progressively adopted blended learning strategies that merge traditional pedagogical approaches with digital tools such as online platforms, interactive software, and accounting applications. These strategies have been instrumental in promoting increased learner engagement, fostering critical thinking skills, and enabling learners to work actively with accounting concepts in a dynamic, learner-centred environment, consistent with principles of constructivist learning theory (Banihashem et al., 2022).

However, the findings exposed considerable challenges that undermine the smooth and effective integration of technology in teaching Grade 10 accounting. Major barriers identified include insufficient teacher training in ICT and pedagogical strategies for technology use, limited access to necessary technological resources such as computers, internet connectivity, and specialised software, as well as technical difficulties experienced during instruction. These constraints have been compounded by systemic issues, such as overcrowded classrooms and resource inequities, which are particularly pronounced in rural and under-resourced schools (Msomi et al., 2025; Starkey, 2020). The digital divide creates disparities in learners' access to technology, which manifests in inconsistent learning outcomes and varying levels of digital literacy and accounting proficiency. Furthermore, the study highlighted a gap between teacher preparedness and the demands of the curriculum. While the post-pandemic era necessitated a rapid shift towards online and blended learning, many teachers lacked confidence and competence due to inadequate professional development opportunities, which limited their ability to effectively employ technological tools and digital pedagogies in accounting instruction (Sangster, Stoner, & Flood, 2020; Nkomo et al., 2021). This challenge is mirrored by learners, many of whom face their own technological skills deficits and attitudinal resistance towards technology-enhanced learning, with some preferring traditional learning modes due to unfamiliarity or discomfort with digital environments.

The curriculum has evolved, introducing complex topics such as auditing, internal controls, and financial analysis, which necessitate a deeper conceptual understanding supplemented by technological proficiency (Msomi et al., 2025). Yet, this expansion raises

concerns about cognitive load for learners who may simultaneously master intricate accounting concepts and sophisticated software functionalities. Effective scaffolding and instructional design are crucial for bridging the gap between theoretical knowledge and practical application through technology. Importantly, the study found evidence that where technology integration succeeds, it not only sustains instructional continuity during crises such as COVID-19 but also enriches learning experiences. Use of tools such as Microsoft Excel, virtual classrooms, and online collaborative platforms facilitated interactive lessons, timely feedback, and peer learning opportunities. These tools enhance learners' digital literacy, which is critical for the contemporary accounting profession, as it is increasingly automated and data-driven (Agustina & Setiawan, 2020; Haleem et al., 2022).

The study contributes to understanding how the integration of advanced technology in Grade 10 accounting teaching resonates with constructivist learning theory by fostering active, learner-centred environments that enhance critical thinking and real-world application. The high uptake of digital platforms and software tools among teachers reflects a progressive adoption of pedagogical strategies that empower learners to engage collaboratively and construct knowledge interactively. However, the findings reveal substantial barriers that hinder the full realisation of these theoretical ideals, including inadequate teacher training, limited resources, and uneven access to technology for learners. These constraints understand the pressing need for comprehensive, context-sensitive professional development that enhances educators' technological, pedagogical, and content knowledge, enabling them to effectively facilitate constructivist learning through digital means. Similarly, addressing infrastructural inequities is crucial to support equitable learner participation and the acquisition of digital literacy. Beyond confirming the theoretical benefits of technology in education, this study offers practical insights for policymakers and educators. The study emphasises strategic investments in technology infrastructure, sustained teacher capacity building, and curriculum enhancements that explicitly embed digital literacy alongside accounting competencies. These measures could better align teaching practices with constructivist principles, enriching educational experiences and preparing learners for a technologically advanced accounting profession.

9. RECOMMENDATIONS

The study recommends integrating advanced technology into Grade 10 accounting education within South Africa's resource-diverse context. Prioritising continuous, context-specific professional development for teachers is essential, focusing on building technological, pedagogical, and content knowledge (TPACK). Training could be hands-on, sustainable, and include peer mentoring and communities of practice to improve both technical proficiency and pedagogical skills. Addressing the digital divide requires strategic resource allocation and improved infrastructure, ensuring equitable access to devices, reliable internet, and curriculum-aligned software, particularly in rural and under-resourced schools. Strategic resource allocation could be essential to ensure equitable access to devices, reliable internet connectivity, and curriculum-aligned software, particularly in rural and under-resourced schools. Extending technology access to learners' homes through partnerships with community organisations and stakeholders may further support blended learning models. Supporting technology access at learners' homes through partnerships could further facilitate blended learning. Regular revision of assessments to integrate technology use is recommended to incentivise learner engagement with digital tools.

Updating the curriculum to explicitly embed digital literacy alongside accounting principles is critical. Curriculum and assessments could promote technological competence through authentic, scaffolded tasks reflecting real-world accounting scenarios. Similarly, learning training programs could bridge technical skill gaps with incremental digital literacy modules, motivational strategies, and peer learning to reduce resistance and build confidence. Fostering collaborative learning communities among teachers could encourage sharing of best practices and collective problem-solving. Robust technical support systems, featuring dedicated IT personnel and accessible troubleshooting resources, are vital to minimise disruptions and sustain engagement. Pedagogical approaches may adapt to learner diversity and software complexity by segmenting lessons, integrating formative assessments, and leveraging flipped classrooms and project-based learning to connect theory with practice. Addressing language and cultural barriers through translated materials and responsive teaching practices may enhance inclusion. Address language and cultural barriers through the use of translated teaching materials and responsive pedagogical strategies that accommodate diverse learner backgrounds, enhancing inclusion and equity in technology-enhanced accounting education.

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Section 2

Teaching and Learning

Chapter # 16

SELF-EVALUATION AMONG FIRST-YEAR UNIVERSITY STUDENTS: ANTICIPATED PERFORMANCE IN ACADEMIC ASSESSMENTS

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ABSTRACT

This study explores university students' self-perception regarding their preparation and expectations for grades compared to the results obtained in an exam. Involving 134 freshmen from a bachelor's degree program, the survey compared students' predictions about their grades with those they actually achieved. The results highlighted a significant discrepancy between expectations and performance, with many students tending to overestimate their own preparation, especially those with unsatisfactory results. The analysis also revealed a relationship between the type of secondary school attended and grade expectations, with students from technical and vocational schools often having higher expectations compared to those from high schools. The study suggests that a lack of familiarity with university evaluation methods and the effects of previous school socialization could influence students' perceptions.

Keywords: self-assessment, grade expectations, performance in evaluation sessions, school-university transition.

1. INTRODUCTION

This contribution focuses on students' self-perception as they approach a university exam, comparing it to the results they ultimately achieve. The aim is to assess their awareness of their level of preparation and the resulting expectation of achieving a certain grade, examining the students' self-assessment capabilities based on the effort they believe they have put into studying, the method they adopted, and the time dedicated. Therefore, it also involves assessing the students' ability to adequately interpret the expected performance standards within the higher education system. This aspect is particularly relevant for freshmen, who face evaluation practices and reference standards that are often very different from those encountered in secondary education.

The transition from high school to university is not only an educational shift but also a milestone in the maturation and development process of young people. With the gradual decline of the manufacturing sector, which previously encouraged more vocationally oriented high school paths, tertiary education has been increasingly excluded (with the exception of ITS programs) (Ballarino, 2013; Valero & Van Reenen, 2019; Almalaurea, 2023) or limited to certain categories of students with an academic inclination from the end of lower secondary school. Currently, post-diploma educational choices are increasingly motivated not only by professional placement, but also by the status associated with academic degrees, personal satisfaction, and interest in specific fields of study. The impact of this transformation is visible in the rising number of freshmen in all degree programs at Italian universities, with a

steady trend since 2015 (ANVUR, 2023). University admission for bachelor's programs is not subject to entrance selection processes, and any type of high school diploma allows students to enroll in any academic path.

In order to improve our understanding of self-perception regarding preparation for exam, an exploratory study was conducted on the self-assessment abilities of first-year students in a specific mandatory course within the curriculum of a bachelor's degree program. The study took place at the University of Turin (Italy), a large institution where enrolments are steadily increasing (+5% in bachelor's degrees and +20% in master's degrees for the 2023-2024 academic year). However, the university also experiences a higher-than-average drop-out rate, with 18% of students leaving the University of Turin during their first year, compared to the national average of 10%.

2. BACKGROUND

The issue of student learning assessment within university systems has been described as an “issue of real urgency” (Brown, 2014), due to its close connection with innovation in higher education. In fact, it is a relatively recent area of inquiry, having received little scholarly attention until the 1990s (Boud, 1995), and only in the past few decades it emerged as a significant topic of interest (Glasner & Brown, 1999; Pastore et al. 2025; Yan, 2022). The concept of assessment previously adopted in Italian universities was largely limited to the certification of student learning, delegated exclusively to instructors, with minimal or no active involvement of students in the process (Aquario & Mazzucco, 2016; Grion, 2016; Doria & Grion, 2020; Coggi, 2020).

In contrast, self-assessment represents an important asset for educational systems, as the literature recognizes its crucial role in fostering autonomous and reflective learning processes among students. Self-assessment assigns an active role to learners and fulfils a fundamental educational purpose that goes beyond the acquisition of curricular content. It encourages the development of responsibility for one's own learning, promotes critical thinking through ongoing monitoring of one's progress in both content and learning methods (Stiggins, 2005; McMillan & Hearn, 2008; Sambell et al., 2013; Taylor, 2013; Adachi et al., 2018; León et al. 2023). From this perspective, self-assessment—understood as a qualitative evaluation of both the learning process and its outcomes (Panadero & Alonso-Tapia, 2013)—can be conceptualized as a learning experience in itself, realized through a continuous process of self-regulation driven by metacognitive engagement (Trinchero, 2023).

Within this trajectory, academic adjustment becomes essential. This refers to students' ability to cope with academic challenges, critically engage with learning methodologies, organize their time effectively, actively participate in lectures, and accurately interpret instructors' expectations (Floris et al., 2023). This process is shaped by individual factors linked to pre-university attributes developed both within the family context and during secondary education. These attributes tend to show their robustness—or, conversely, their weaknesses—particularly during the first academic year.

Another crucial aspect is students' sense of self-efficacy, as defined by Bandura (2000), who argues that a strong capacity for self-assessment enhances students' likelihood of achieving positive academic outcomes while reducing the risk of dropping out.

In the Italian education system, transitions between educational cycles—particularly the shift from secondary to tertiary education—are especially challenging. This is likely due to the limited availability of orientation and support mechanisms offered by educational institutions. As a result, students are more vulnerable to academic failure, dropout, and an underestimation of the effort required in the next stage of education. Anticipatory

socialization between educational levels is also severely limited, especially during the transition from upper secondary school to university.

The academic success is influenced not only by cognitive factors but also by satisfaction, perseverance, the activation of motivational processes, and the ability to engage in critical self-assessment (York et al., 2015; Karaman, 2021; Yan et al., 2023). Within this process, academic adaptation becomes essential, defined as the ability to adjust to academic challenges, understand and critically reflect on study methods, adopt effective time management, actively participate in classes, and properly decode the expectations of instructors (Floris et al., 2023). Another crucial aspect is the students' sense of self-efficacy, where a good self-assessment of one's abilities increases the likelihood of achieving good results and reduces the risk of dropout. For an individual to possess such self-assessment ability, awareness and control over one's cognitive processes—i.e., metacognition—are necessary. This manifests in the ability to select appropriate strategies for preparation and study in general, engage in evaluating one's understanding of the content provided by instructors, and assess one's level of knowledge. The development of a self-assessment literacy regarding academic performance thus becomes a fundamental part of the broader learning process (Galliani, 2015; Serbati et al., 2019).

With particular reference to higher education, self-assessment is increasingly moving toward so-called sustainable assessment, understood as a process that shapes future orientation and that “prepares students to meet their future learning needs” (Boud & Soler, 2015, p. 400). To achieve this goal, assessment processes should combine forms of self- and peer assessment, giving particular space to peer-review practices (Grion & Tino, 2018), thus placing the peer group at the center. Finally, the role played by anxiety and stress in academic performance at all levels cannot be overlooked. In the academic context as well, anxiety and stress associated with exam preparation and completion affect not only assessment outcomes but also undermine self-esteem, impair realistic self-assessment, fuel fear of failure, and consequently lead to a loss of self-efficacy (Lucangeli, 2019; Blaas, 2014).

3. THIS STUDY: OBJECTIVES, DESIGN AND METHOD

In order to better understand the perception that students have of their level of preparation and, consequently, their expectations regarding the grades they will achieve in the exams, the present study involved 134 students. The participants were freshmen enrolled in the first year of a bachelor's degree program, attending the “General Sociology” course.

The students involved in this study are enrolled at the University of Turin (Italy), a large and expanding institution, where enrolment rates have shown a steady increase (+5% in bachelor's degree programmes and +20% in master's degree programmes; source: University of Turin, Academic Year 2023–2024, consolidated data). However, the university dropout rate is higher than the national average, with 18% of students withdrawing during their first year.

First-year students are supported through various welcoming and guidance tools, ranging from assistance with formal administrative procedures to initiatives such as “A Day in the Life of a Freshman”, “Welcome Days” organised by degree programmes, and a wide range of orientation activities such as “University Open Days” and the mobile app *Orienta#UniTo*. These initiatives aim to foster a culture of assessment, enhance student responsibility throughout their academic journey, and promote greater student engagement and agency within university life.

Before the start of the exam, which took place in December 2024, students present in the classroom were asked to answer the question, “What grade do you think you will get on this exam?” in order to compare this self-assessment with the grade they ultimately achieved. This simple question (it should be noted that students were not required to respond) was accompanied by a recommendation to answer only after careful and honest consideration of several aspects that characterized their preparation for the exam, which could contribute to making the self-assessment valid. These aspects included: attention during lectures, effort put into studying and its organization, feedback received from the instructor during exercises, and so on.

The exam consisted of a written test with 30 multiple-choice questions. The grading criteria for the exam involved awarding one point for each correct answer and penalizing half a point for each incorrect answer. A perfect score of 30/30 could be achieved by answering all the questions correctly. The Italian grading system has specific features that significantly differ from those in many English-speaking countries. It uses a numerical scale up to 30, with 30 representing excellent performance—with the possibility of adding “lode” (“with merit”) for exceptional performances—and 18 being the minimum passing grade. Unlike many systems where grades are determined cumulatively through courses, quizzes, and tests throughout the semester, the Italian university grading system often relies on a single final exam, either oral or written. This exam usually covers all the material taught during the course, making exam preparation crucial for success.

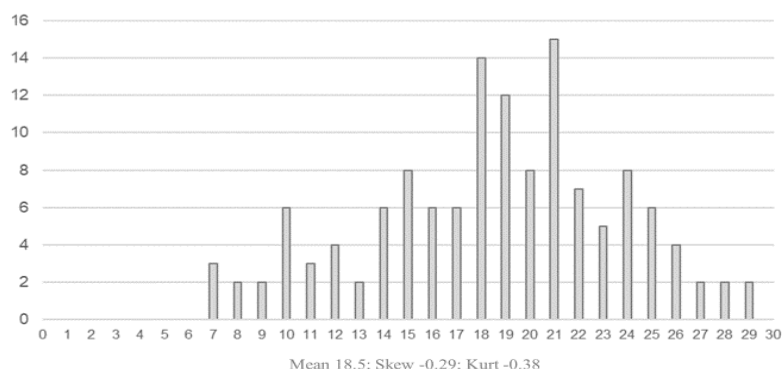
We analyzed the sample as follows: 72.5% of respondents identified as female, while 27.5% identified as male. This data indicates a clear predominance of female students, a trend that has characterized humanities, legal, and social sciences study paths in Italy for several years, with the University of Turin being no exception.

Among the freshmen interviewed, 61.4% hold a diploma from the academic (lyceum) track, while 38.6% come from technical or vocational secondary school backgrounds. In the Italian secondary education system, upper secondary school lasts five years (typically between ages 14 and 19) and is divided into three types of pathways: lyceums (academic high schools), technical institutes, and vocational institutes, each comprising numerous specializations.

Enrolment in these pathways is strongly correlated with students’ social origins and their performance in lower secondary school. Typically, the academic track is chosen by students from middle-class and bourgeois backgrounds with good or excellent prior academic achievement, while technical and vocational tracks tend to be attended by students from working-class backgrounds with average or low previous performance. These three pathways differ not only in curricula but also in opportunities, experiences, and extracurricular activities.

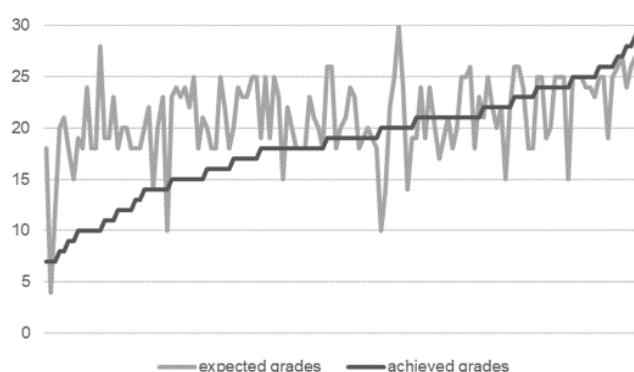
The result of the exam on which this study is based was generally unsatisfactory, with a significant portion of students (about 35%) failing to reach the minimum passing grade of 18, and no student achieving the highest score. The following figure (Figure 1) shows the distribution of scores. The lowest score was 7, awarded to 3 students, while the highest score was 29, awarded to 2 students. This distribution highlights a concentration of grades between 18 and 21, corresponding to the lower range of the grading scale (the minimum passing level or slightly above). This suggests that students may not have applied adequate study methods and/or sufficient time to achieve a more satisfactory performance.

Figure 1.
Achieved grades, scores from 0 to 30 (N 134).



The next step undertaken in our analyses consisted of a comparison between each student's predicted grade with the grade they actually achieved (Figure 2).

Figure 2.
Expected grades vs. achieved grades, scores from 0 to 30 (N 134).



As can be seen, there are very few cases of perfect alignment between the predicted grade and the grade actually achieved (specifically, 7 cases). However, many students predict a grade that is close to the actual result, with a discrepancy of only a few points. Nonetheless, a significant number of students seem to lack awareness of their performance in terms of university grading. In particular, there is a noticeable tendency for students with unsatisfactory results—and thus inadequate preparation—to overestimate their performance. On the other hand, students with the best results appear to have underestimated their preparation predicting outcomes lower than those they ultimately achieved.

This evidence suggests that students do not have an adequate perception of the preparation required to successfully face university examinations, resulting in distorted expectations. It is also possible that freshmen have not acquired, during their recently completed secondary education, the necessary skills to independently and responsibly

organize their study time, without the direct guidance of teachers, as is required in tertiary education courses.

We now turn to an examination of the relationship between students' grade expectations and selected characteristics of their prior educational background that are deemed relevant. Specifically, we focus on the type of secondary school attended (which has been categorized into two tracks for simplicity: lyceum and technical-vocational school) and the final high school grade obtained (Table 1). High expectations are those expressed by students who predict a grade higher than the one they ultimately achieved, while low expectations are those expressed by students who predict a grade lower than the one they actually obtained. The few cases of exact predictions were not considered.

Table 1.
Expectations based on the type of secondary school attended and the diploma grade.

Type of secondary school		Diploma grade	
		Medium-low	High
Lyceum	High expectations	56%	76.9%
	Low expectations	44%	23.1%
	Total	100%	100%
Technical-vocational school	High expectations	70.6%	58.8%
	Low expectations	29.4%	41.2%
	Total	100%	100%

The observation of the data shows that the type of secondary school attended appears to be significant in shaping students' expectations and, by extension, their self-assessment abilities. Specifically, students with a lyceum diploma tend to have a lower tendency to overestimate their abilities, especially when they completed their secondary education with a medium-low grade, compared to students from a technical-vocational school. On the other hand, students from a technical-vocational school, when they completed their secondary education with a high grade, seem to be insecure about their preparation and display lower expectations compared to students with a high diploma grade from a lyceum track.

This distribution suggests that freshmen from technical and vocational tracks, which have lower social prestige and where teachers have lower expectations compared to those teaching in lyceums, may be less equipped in terms of self-assessment skills. It is worth noting, however, that regardless of the track attended, freshmen generally have relatively high final grades on their high school diploma exams, with only 16% having obtained a sufficient or slightly higher diploma grade. Nearly 30% of students achieved the highest possible score. This could be attributed to a structural characteristic of the Italian educational system, namely the tendency to assign high grades. This widespread evaluative practice, also referred to as “soft-grading” or “easy-grading” (De Paola, 2011), regards the grade not only as a direct consequence of performance but also as a tool for motivation and for strengthening the teacher-student relationship.

This aspect is of interest because it may contribute to a socialization into a self-assessment culture that is somewhat unrealistic. Therefore, it is already in high school that students acquire, alongside knowledge, the necessary skills to manage the transition to the next level of education, to self-assess adequately, and to approach university exam preparation with confidence.

4. LIMITATIONS OF THIS STUDY AND FUTURE RESEARCH

This study has several limitations: a small sample size, lack of representativeness, and self-selection of participants as it was up to the individuals whether to respond. It is, in fact, an exploratory study aimed at better understanding the expectations of freshmen regarding their success in a university exam.

These limitations are expected to be addressed through a deepening and expansion of the study, to be conducted in the next academic year 2025-2026, with the following objectives: increasing the sample size, adding questions on social origin, adding questions on study motivation, differentiating degree programs and disciplines (with a distinction between Humanities and STEM programs), involving other Italian universities with their respective degree programs and courses, and including heterogeneous assessment methods (such as multiple-choice tests, open-ended questions, mixed-format exams, etc.).

The expansion of the study in terms of sample size and the variety of information collected is hoped to allow for a broader understanding of students' expectations through the use of more sophisticated statistical analyses and the consideration of other influencing factors.

5. DISCUSSION AND CONCLUSIONS

The results of this study highlight the presence of a relationship between previous schooling experiences and the self-assessment of one's performance during the first university exams. The explanations considered in this study pertain to individual factors, but we do not exclude the influence of organizational or institutional reasons.

Among the individual reasons, it can be noted that the students involved in the study are freshmen, and therefore still not very familiar with university evaluation methods. Additionally, they are socialized into evaluation criteria that are not particularly strict in high school, at least for students in technical and vocational tracks. To explain the misperception, the so-called "Dunning-Kruger effect" is also considered, as identified by David Dunning and Justin Kruger (1999). They highlighted how less competent individuals tend to overestimate their abilities, often due to a lack of awareness of their own limitations, while more competent individuals tend to underestimate their abilities due to excessive self-criticism.

It is well established that competent support from parents with higher educational qualifications—or the lack thereof, in the case of parents with lower levels of education—can significantly influence students' academic experiences (Triventi, 2014). This study did not collect data on the social background of the students' families; therefore, it was not possible to directly estimate this influence. However, it is possible to hypothesize, indirectly and through the analysis of students' upper secondary school qualifications, that there is a long-lasting effect of social origin that influences both academic performance and students' ability to adapt to the demands of the higher education system.

Among the institutional/organizational reasons, we can point to the possibility offered to the students at the University of Turin involved in this study to "attempt" the exam in numerous sessions (up to eight per academic year) without any limits on the number of retakes. This large number of attempts might not encourage students to develop and strengthen self-assessment skills which are necessary to decide whether or not to take an exam when the opportunities are more limited. As a result, in Italy—unlike in other countries—the proportion of students who extend their studies well beyond the official duration of their degree programs is particularly high. These so-called "fuori corso" students

(students not completing their degree on time) often turn university education into a kind of “perpetual moratorium” on adulthood, rather than experiencing it as a phase of socialization and preparation for adult life.

Despite the limitations outlined, and based on the evidence collected, this study leads to recommendations aimed at strengthening the existing support and orientation actions for freshmen at the University of Turin, such as tutoring for completing formal procedures, initiatives like “A Day as a Freshman” and “Welcome Freshmen”. It is hoped that these will be complemented by increasingly individualized support actions for each freshman, as well as real opportunities for bridging the gap between high school and university to facilitate the transition.

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Chapter # 17

DEVELOPING CRITICAL THINKING SKILLS IN SECONDARY SCHOOL LEARNERS USING EDUCATIONAL PHILOSOPHIES:

South African teachers' perspectives

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ABSTRACT

Critical thinking is one of the highly recommended skills for the 21st century that young people should cultivate from secondary education to prepare them for the future of work. This chapter examines how secondary school teachers use educational philosophies in classrooms to develop critical thinking skills in learners. The study used a qualitative research approach and a multiple case-study design to understand the participant teachers' perspectives. The study population consisted of Grade 10-12 secondary school teachers within the Buffalo City Metro (BCM) District in the Eastern Cape, South Africa. The sample size consisted of 12 teachers. Purposive sampling was used to select the participant teachers for semi-structured and focus group interviews. The study used thematic analysis methods to analyse data. The findings reveal that teachers practised social constructivism and progressivism as educational philosophies to develop critical thinking skills in their learners. The authors conclude that developing critical thinking skills in secondary school learners by using relevant educational philosophies could result in preparing them for the future world of work or tertiary education. To develop critical thinking in secondary school learners, the study recommends that the Department of Education and policymakers should implement ongoing teachers' continuous professional development that involves hands-on strategies for teaching each subject in classrooms.

Keywords: critical-thinking skills, progressivism, secondary school, social constructivism, South Africa, teaching and learning philosophies.

1. INTRODUCTION

Critical thinking skills are one of the important 21st-century soft skills that young people need to develop from secondary school to prepare them for the future world of work or tertiary education.

To achieve this goal, secondary school teachers ought to use appropriate types of educational philosophies in classrooms that will help learners develop critical thinking skills (Kagaba, 2025; Wahid, 2022). In the context of the present study, this argument implies that teaching and learning philosophies practised by secondary school teachers impact not only the acquisition of problem-solving skills, but also the academic performance and prepare learners for the future of work. To explore the matter further, the present chapter examines educational philosophies used by secondary school teachers to help Grades 10-12 learners develop critical-thinking skills in South Africa.

The main argument of the chapter is that, where there are adequate resources for teaching and learning, practising suitable educational philosophies in classrooms will help teachers develop critical thinking skills in their learners, hence prepare them for the future

world of work. Drawing from philosophical and educational foundations, the present authors define critical thinking as reflective and purposeful reasoning that involves metacognition, analysis, and evaluation (Alsaleh, 2020). Critical thinking is also a component skill of problem-solving, decision-making, and creating strategies to investigate and explore physical and conceptual spaces.

After the introduction, the rest of the chapter is organised in eight main sections. The next section is the background of the study, followed by the problem statement and study aim. Section four entails the theoretical framework, followed by the literature review. Section six discusses the research methodology used to collect the data. Section seven presents the data collected through the interviews, followed by the discussion of the findings. The last section concludes the study.

2. BACKGROUND OF THE STUDY

Critical thinking has emerged as one of the crucial skills for the 21st century, essential for effective problem-solving, informed decision-making, and democratic engagement. Critical thinking skills are important in education because they are unique and highly valued cognitive skills, characterised as one of the “four Cs” alongside communication, collaboration, and creativity (Daflizar & Alfian, 2023; Kagaba, 2025). For that reason, it has become highly important that secondary school teachers develop critical thinking skills in learners by using appropriate education philosophies and teaching strategies. In other words, there is a relationship between philosophies of teaching and learning adopted by a teacher and learners’ acquisition of critical thinking skills. Similarly, Leng (2020) argues that if the educational philosophy practised by a teacher does not include active engagement of learners, metacognition, analysis, and evaluation, then they cannot develop critical thinking skills, hence potentially perform poorly in that subject.

Through the Curriculum and Assessment Policy Statement (CAPS), the South African Department of Basic Education (DBE, 2011) has embedded critical thinking in the curriculum of secondary school. The DBE introduced a new teaching strategy in the South African Curricula to promote critical thinking. Project-based learning (PBL), problem-based learning (PBL), inquiry-based learning (IBL), and case-based learning (CBL) have been implemented at secondary schools to develop critical thinking skills among learners. However, scholars such as Nikkola et al. (2022) and Leibovitch et al. (2025) have criticised South Africa’s CAPS, arguing that it is more prescriptive and content-heavy, thereby contributing to the challenges teachers face in integrating certain teaching strategies. The CAPS also requires a structured, assessment-driven approach in the classroom, a factor that may prompt teachers to prioritise curriculum completion over encouraging learners’ involvement in collaborative and critical thinking activities (Leibovitch et al., 2025). Thus, time available for developing critical thinking skills is also a significant challenge.

South African classroom realities present some barriers in implementing educational philosophies to develop critical thinking skills in secondary school learners. The first barrier consists of overcrowded classrooms (West & Meier, 2020). Overcrowded classrooms hinder teachers from using appropriate teaching and learning strategies that can help learners develop critical thinking skills. Though there are various policy initiatives to address learner-to-teacher ratios, overcrowding is a persistent and systemic problem in South African public schools (Tshangana et al. 2023). The second significant barrier is curriculum overload. Thornhill-Miller et al. (2023) note that curriculum overload in South Africa negatively impacts teaching and learning outcomes. In this connection, O’Reilly et al. (2022) reported that CAPS can limit teachers from implementing teaching and learning strategies as they are

obliged to rush through content to meet curriculum requirements. As a result, teachers leave a limited time for reflective teaching practices and class activities.

A third major barrier is a lack of resources or teaching and learning materials in many South African schools, hindering the promotion of critical thinking skills (Leibovitch et al., 2025). Under-resourced schools are heated. This challenge is worse in under-resourced schools and in the schools located in rural areas (Makeleni et al., 2023; Zondo, Human-Vogel & Omidire, 2025). The lack of resources entails textbooks, learning materials, assessment tools, and internet connectivity. In some schools, learners often share a textbook in groups of five to seven and cannot complete homework, particularly in disadvantaged community schools (Leibovitch et al., 2025; Makeleni et al., 2023). These challenges imply that secondary school learners cannot develop critical thinking skills if teachers cannot practise relevant teaching and learning philosophies to achieve desired goals.

3. RELATIONSHIP BETWEEN TEACHING PHILOSOPHY AND PRACTICE

A strong connection between teaching philosophy and practice makes teaching purposeful in terms of developing critical thinking skills in learners. As a set of beliefs, teaching philosophy guides teachers on why and how they teach, while practice is the actual implementation of teaching style in the classroom (Leng, 2020). Teaching philosophy and practice should be deeply connected, with teaching philosophy informing teaching methods and practice (teaching style, classroom management, assessment choices, and interaction with students), revealing the connection, and encouraging reflection to create planned, effective learning experiences. In other words, educational philosophy guides practice in the classroom.

Teaching philosophies are significant because they outline the roles and duties of teachers in the classroom. Philosophies enhance the ability of teachers to develop solid reasoning and understanding (Ulubey & Alpaslan, 2022). Consequently, teachers develop solid reasoning and understanding to identify educational practices that have failed and design strategies for the improvement of these failed practices. In the context of China, Leng's (2020) study revealed that the practice of specific educational philosophies motivated secondary school learners to engage in academic activities that stimulated their cognitive development.

Furthermore, teaching philosophies can have a significant influence on the performance of learners in various ways. When teachers have a clear understanding and application of teaching philosophies, they can create a positive learning environment that promotes active engagement, critical thinking, and problem-solving skills in learners. In the context of Nigerian secondary schools, Jabaar's (2018) study revealed that teachers still carried out traditional learning styles of teacher-centred learning. In addition, teachers did not practice appropriate philosophies of teaching and learning to allow them to effectively engage with learners and promote active learning. As a result of teachers practicing incorrect philosophies, poor academic achievement among secondary school learners was evident.

4. PROBLEM STATEMENT AND STUDY AIM

The concern in this chapter is that many secondary school learners complete their secondary school education in South Africa without acquiring soft skills such as critical thinking and problem-solving skills, which could help them in their future work environment

and tertiary education (DBE, 2022; Zondo et al., 2025; Phillips, 2023). The problem lies with teachers facing various challenges hindering them from practising educational philosophies in classrooms to develop critical thinking skills in learners. Besides the inadequate professional development for teachers, the significant challenges are the curriculum overload (Thornhill-Miller et al., 2023), a lack of resources in terms of instructional materials (Leibovitch et al., 2025), overcrowded classrooms (West & Meier, 2020), and time constraints (O'Reilly et al., 2022). Yet even when resources are available, another significant and often overlooked barrier to fostering critical thinking lies in teachers' continuous professional development. As a result, the teaching and learning process tends to emphasise rote memorisation and fundamental material knowledge instead of teaching methods that promote higher-order thinking. Therefore, the chapter aims to examine teaching and learning philosophies that secondary school teachers use to develop critical thinking skills in learners in South Africa.

5. THEORETICAL FRAMEWORK

The study utilised the social constructivist learning theory as a theoretical framework. Social constructivism was coined and developed by Lev Vygotsky in 1968. Vygotsky envisioned that knowledge would be socially constructed using interaction with people in various contexts (Frederick-Jonah, 2022). Social constructivism theory is an educational learning theory that emphasises learners' role in constructing their own knowledge in learning through reflection. Learners construct knowledge and acquire skills through "reflection and active construction process occurring in the mind of individuals" (Brau, 2020, p. 6). In other words, learners accumulate new knowledge through exploring and inquiring about activities with their peers during learning. The theory is based on the premise that learners construct new ideas based on their own prior knowledge and experiences.

Constructivism is suitable for the study topic because it shifts learning from passive reception to active knowledge creation. Social constructivism theory "focuses on interaction, collaboration, and group work for effective learning" (Akpan et al., 2020, p.50). It stresses self-discovery, problem-solving, and deeper understanding through real-world application (Frederick-Jonah, 2022). Furthermore, it promotes self-guided exploration, making learners responsible for their learning process, improving motivation, and fostering independent thinking for critical analysis. Therefore, applying the social constructivist learning theory in secondary schools can be useful because learners engage freely in classroom activities that ignite cognitive skills such as problem-solving and critical thinking (Ullah et al., 2020). As a result, learners gain new knowledge through self-reflection, group discussions, and evaluation in the classroom.

6. LITERATURE REVIEW

It is important to examine the debate in the literature about the most used philosophies of teaching and learning that promote critical thinking skills. These are humanism, constructivism, and progressivism. Firstly, Humanism is a learner-centred philosophy that focuses on developing soft skills to build human relationships and to acquire valuable knowledge (Tolstova & Levasheva, 2019). The proponents of this philosophy believe that learners should be actively involved with their education on all levels and should be able to choose what they will be learning (Tahirsylaj, 2017). In this philosophy, teachers are seen as facilitators and partners in learners' growth, rather than directing the learning process (Fries,

2012). Humanism emphasises the importance of self-directed learning, discovery, and experiential learning, where learners assume responsibility for their education.

Secondly, in a constructivist philosophy, the teacher only acts as a source of information (Aslan, 2018). The teacher encourages the learner to use different tools and methods to seek information and resources. Aung (2020) notes that this philosophy uses a more hands-on approach by allowing learners to construct their own ideas. Furthermore, Ahmad, Sultana, and Jamil (2020) describe constructivism as the knowledge that is constructed based on own experiences and reactions to environments. Constructivism emphasises the active role of learners in the learning process and encourages them to construct their own meaning of the world through hands-on, minds-on, and authentic learning experiences. A study conducted by Sawers, Wicks, Mvududu, Seeley and Copeland (2016) indicate that active, collaborative learning and knowledge creation by learners are more effective than traditional models of learning, in which learners are passive recipients of information.

Thirdly, progressivism is a philosophy that focuses on how individuals participate in activities. It emphasises the learners rather than the content they are taught (Alsalem, 2018). This idea stems from Dewey's theory, which suggests that more care and consideration should be given to the reformation of experience (Williams, 2017). Progressivism views education as a means for social reform, and learners are encouraged to engage in critical thinking and social action to effect positive change in society. Therefore, teachers who use this philosophy must be flexible and adaptable to keep up with changes in the educational landscape (Alanoglu et al., 2022). Overall, the progressive philosophy of education promotes a learner-centred approach to learning that emphasises experimentation, critical thinking, and the active engagement of learners in the learning process.

7. RESEARCH METHODOLOGY

The researchers used the interpretative paradigm to conduct the study and achieve its purpose. Kivunja and Kuyini (2017) define the interpretivist paradigm as a theory where emphasis is placed on trying to understand and interpret the viewpoint of the participants or how they interpret contexts. The interpretative paradigm helped the researchers interpret participants' viewpoints and analyse the data using thematic analysis. Kiger and Varpio (2020) argue that in interpretative research, researchers intend to understand how participants construct reality. The interpretive paradigm helped the researcher to understand the philosophies of teaching and learning that secondary school teachers practice.

The researchers used a qualitative research approach in the form of a multiple case-study research design to understand the phenomenon explored from the perspective of the participants. A multiple-case study design is defined as an in-depth analysis of an occasion or occurrence of a naturalistic phenomenon (Tracy, 2019). Following the view of Majid (2018), when applying the multiple-case study design to this study, the researchers determined that the secondary school teachers who identified their philosophies of teaching and learning were considered the "multiple cases".

7.1. Study Population and Sampling

The study population consisted of 43 secondary school teachers from Circuit Five (5) within the Buffalo City Metro (BCM) District in the Eastern Cape. The study considered Grades 10 -12 teachers only. The sample size consisted of 12 secondary school teachers. The researchers selected three (3) schools within the district. To avoid bias in the process of

selecting the participants, four (4) teachers were considered from each school to make a sample size of 12 participants for the semi-structured and focus group interviews.

The study used the purposive sampling method to select 12 teachers. Kumar (2011) notes that purposive sampling relies on the researcher's own judgment to select suitable participants who hold information to meet the research objectives. Purposive sampling was appropriate for this study because the teachers were recruited based on selection criteria. The researchers sought to find the best possible participants that would suit the criteria set out or created by the researcher.

A school was selected if its language of instruction is mainly English and has more than four teachers in Grades 10-12. Similarly, a teacher was selected if he/she had a relevant teaching qualification to teach in South African schools with at least five years of teaching experience at secondary schools and teaching a subject in Grades 10-12 during the time of the data collection process.

7.2. Data Collection and Analysis

To obtain reliable data from the teachers, the researchers conducted one-on-one semi-structured interviews and focus-group interviews. The researchers could not collect data through classroom observations because of restrictions linked to the permission letter to conduct research from the Department of Basic Education. Semi-structured interviews are conducted individually with participants and consist of a combination of open- and closed-ended questions on topics which the researcher wants to address (Adams, 2015). The researchers conducted semi-structured interviews with the 12 secondary school teachers who formed part of the sample size. The focus-group interview with 12 teachers sought to understand the perspectives and experiences of the participants in the study. The reason behind choosing a focus-group interview was to gain detailed information on the philosophies of teaching and learning that participating teachers used in the classroom (Nyumba et al., 2018). A focus-group interview helped collect rich data that was not revealed during one-on-one interviews.

This study used the thematic analysis method to analyse data from semi-structured interviews and focus group interviews. Kiger and Varpio (2020) define thematic analysis as an analytical-qualitative method used to understand experiences across a data set. The thematic analysis helped identify themes from data that proved to be beneficial to address the research question of this study (Maguire & Delahunt, 2017). Once the data were collected, the researchers analysed the meanings attached to the set of data and were able to use the analysis to determine the philosophies of teaching and learning practiced by secondary school teachers.

This study presented some limitations relating to various aspects of the research study. The first limitation was the sample size (3 schools and 12 teachers were included), which affected the generalisability of the research. The second limitation was the absence of classroom observations due to the restrictions on the permission letter to conduct research and the ethics approval letter. These restrictions hindered the ability to obtain the views from the learners rather than relying on self-reporting responses from the teachers.

8. FINDINGS

It was important to examine the formal teaching qualifications of teachers as they may impact the knowledge and practice of educational philosophies to enhance critical thinking skills in their learners. The analysis of the findings revealed that the participants' highest qualifications range from a bachelor's degree in education, a postgraduate certificate in

education, to a Master of Education. These findings suggest that teachers with university degrees or specialised education training may possess a good knowledge of diverse philosophies of teaching and learning. Therefore, their level of qualification could help them select suitable philosophies of teaching and learning to develop critical thinking skills in learners.

Table 1 presents the themes and sub-themes that emerged from both semi-structured and focus-group interviews with the participants. The interview questions related to teaching and learning strategies associated with philosophies that teachers used in classrooms.

Table 1.
Themes and sub-themes about developing critical thinking skills in learners.

Themes	Sub-themes
1. Teaching-learning strategies to implement the teaching & learning philosophy in classrooms	1. Problem-based learning
	2. Class discussions
2. Importance of critical thinking skills in learners	1. Participating in the learning process
	2. Fulfilling the aim and objectives of the subject contents

The themes and sub-themes presented in Table 1 are developed in the next sub-sections. The findings are presented according to the themes and sub-themes with concise analysis. The discussions of the findings are in another section.

8.1. Theme 1: Strategies to Implement Teaching and Learning Philosophy in Classrooms

Teachers used diverse strategies in classrooms to develop critical thinking skills in learners. During one-on-one interviews and focus group interviews, teachers reported that they used a learner-centred approach to motivate their learners to actively engage during the process of teaching and learning. Data presented in the sub-themes below shows that teachers used problem-based learning, and sharing thoughts and ideas as means to implement a specific teaching and learning philosophy.

8.1.1. Sub-theme 1: Problem-Based Learning Strategy

Teachers used a problem-based learning strategy that involved presenting learners with situations or challenges from the real world that called for them to come up with solutions as a team. They stated that problem-based learning was an effective procedure for implementing their chosen philosophy of teaching and learning. Below are the responses that were given by the teachers on the procedure of implementing philosophy. Teacher (P5) explained as follows:

I used problem-based learning to identify problems and interact with learners to determine solutions. A difficult and real-world problem or scenario is presented to start the learning process. This problem is intended to be interesting and applicable to the lives of the learners.

The teacher (P12) commented the following:

The learners in my classroom were provided with challenges and allowed to use probing tactics to gain more understanding of the challenge. I guided them toward developing a solution for each challenge or problem provided.

The findings from the quotes reveal that teachers used problem-based learning as a strategy to develop critical-thinking skills in their learners. As discussed in the literature review section, the learning strategy is linked to progressivism. The quotes indicate that the teachers used to pose problems from real-life contexts to the learners, which helped them understand how the knowledge they acquired can be applied in real-world situations. Problem-based learning strategy helped teachers to establish a dynamic and engaging learning environment that promotes critical thinking, collaboration, and the real-world application of knowledge.

8.1.2. Sub-theme 2: Class Discussions

Class discussions helped implement a philosophy of teaching and learning by creating a learning environment where learners shared ideas and opinions on a topic among peers. Under the guidance of teachers, class discussions motivated learners to collaborate and express their views respectfully. Teacher (P7) explained the process of class discussions by saying:

I allow the learners to contribute to the lesson by discussing and sharing their thoughts and ideas on a topic. This improves their communication skills. Sharing ideas guarantees exposure to various ideas and thoughts from other learners.

Another teacher (P10) stated as follows:

I create an educational environment that is learner-centred through sharing thoughts and ideas. I enable my learners to actively engage with the materials, take responsibility for their learning, and contribute their original perspectives and ideas to the educational process. Along with improving educational quality, this method equips learners with the skills they need for the rest of their lives.

The analysis of the quotes reveals that teachers provided learners with opportunities to improve and enhance their critical thinking skills by encouraging them to engage with and critically analyse the ideas and opinions of their peers. These findings suggest that the application of teaching philosophies that give priority to each learner's unique needs and strengths can be facilitated through class discussions. The quotes suggest that teachers were practising social constructivism as a philosophy of teaching and learning to develop critical thinking in learners. This can be used to put into practice teaching and learning philosophies that place a high priority on the development of critical thinking abilities.

8.2. Theme 2: The Importance of Critical Thinking Skills in Learners

During both one-on-one interviews and focus group interviews, the researchers asked the teacher participants about their perceptions of the importance of critical-thinking skills in their learners and how they helped learners in classrooms. They responded that critical thinking enables learners to carefully process information and identify areas of weakness. The following sub-themes have been generated based on teachers' responses on the importance of critical thinking skills in learners.

8.2.1. Sub-Theme 1: Participating in the Learning Process

Findings from interviews revealed that teachers used to motivate learners to actively participate in their learning process. During interviews, teachers were asked to explain how they motivated learners to participate in the learning process. Teacher (P3) explained as follows:

As a teacher, I allow my learners to participate in the learning process. This allows them to feel included in the lesson and become more confident. I urge learners to assess

what they have learned, identify their areas of weakness, and set goals for future learning.

Another teacher (P3) stated as follows:

Learner-centred practices allow learners to participate in the learning process. By doing this, teachers create a platform where learners broaden their knowledge by learning from others.

The quotes reveal that teachers promoted the active participation of learners in the learning process. Due to learners participating in the lessons, it became easier for the teacher to include them in all discussions and increase their confidence, and seek knowledge by communicating with others. Therefore, teachers have utilised social constructivism as a philosophy of teaching and learning to cater to the tailored needs of learners.

8.2.2. Sub-Theme 2: Fulfilling the Aims and Objectives of Subject Contents

During semi-structured interviews and focus group interviews, teachers stated that they ensured that their philosophy of teaching and learning assists them in achieving the lessons' aims and objectives. In this connection, Teacher (P4) reported as follows:

Teachers are required to set aims and objectives that are central to the subject content. These aims and objectives should be achieved in a specific time frame. This allows learners to focus on the aspects that are relevant and ignore other aspects.

Teacher (P6) said:

I find that aims and objectives are used to track the progress of both the teacher and the learner. I ensure that I teach the correct content and use adequate assessment strategies to test the learner's ability to successfully follow instructions and retain valuable information that I taught them. I need to use the timeframe that has been stipulated by the department to assess the learners.

The findings from the quotes reveal that teachers developed critical thinking abilities in their learners by ensuring that the aim and objectives of a subject are met within a social constructivist framework. Within the framework of social constructivism, learning is framed by the accomplishment of subject aims and objectives. When the aim and objectives are met, it shows that learners have engaged with the content and have gained a deeper understanding of the subject.

This theme, "Importance of critical thinking skills in learners", addresses the philosophies of teaching and learning that teachers use to develop critical thinking skills. It has been established that teachers use a social constructivist approach to meet the different needs of their learners. By doing this, the teachers developed a bond with learners and helped them to solve problems using progressivism as a philosophy of teaching and learning. The social constructivist framework provides a link between teachers and learners by expanding the learners' knowledge and understanding so that they can apply the theory in real-world contexts. Developing creative thinking skills lays a foundation because it is a skill that can be applied in the real world.

9. DISCUSSION OF THE FINDINGS

The evidence from various quotes reveals that teachers used problem-based learning (problem-posing) and group discussions as teaching strategies to develop critical thinking skills in learners. Through teaching strategies, learners were provided opportunities to analyse, evaluate, and thoughtfully apply reasoning to find a solution to a real-world problem (Leibovitch et al., 2025). The findings suggest that secondary school teachers used progressive philosophy to develop critical thinking skills. In support of Alanoglu et al.

(2022), by using the progressive philosophy of education, teachers used a learner-centred approach to learning that stressed critical thinking and active engagement of learners in groups to find a solution to a posed problem. The inference from the findings is that the use of progressive philosophy enhanced competencies that could prepare learners to navigate the complexities of the contemporary world.

The teaching and learning process also consisted of allowing learners to share their thoughts and ideas as learners were placed in groups. The analysis of the findings reveals that there were aspects of interactive learning, collaborative learning, and learner-centred learning. The findings support the argument of Akpan et al. (2020), who state that the social constructivist philosophy can only be implemented if learners create their knowledge and actively participate in learning by sharing what they have learned and experienced. In this case, teachers took on the role of guides and facilitators (Aung, 2020). It is significant to note that no teacher reported the lack of teaching and learning materials; overcrowded classroom was a hindrance to using the above teaching strategies, as it was reported in the studies conducted by Leibovitch et al. (2025) and Zondo et al. (2025). In the present study, most participants indicated that they felt confident in developing critical thinking in the learners because of the copying mechanism to deal with an adequate supply of teaching materials.

The participants did not mention curriculum overload or time constraint as barriers to developing critical thinking in the learners and reaching learning outcomes. They needed to use the timeframe that had been stipulated by the CAPS to teach and assess the learners. These findings differ from those reported by Thornhill-Miller et al. (2023) and O'Reilly et al. (2022). The inference is that there is no contradiction between meaningful critical thinking participation and curriculum demands. Despite the methodological limitations, our study found that teachers successfully used teaching strategies to develop critical thinking skills through collaborative and discussion-based activities as elements of social constructivist philosophy.

Group activities given to the learners were linked to their daily lives and directed to problem-based learning and creativity, hence developing critical thinking skills. This strategy of teaching is linked to progressive philosophy (Alanoglu et al., 2022). As learners learn to evaluate ideas and their importance to their lives and beliefs, they recognise that meaningful engagement with concepts requires careful reflection. In this context, the teachers used progressive philosophy in classrooms.

10. CONCLUSIONS

The study examined educational philosophies used by secondary school teachers to help learners develop critical-thinking skills. The findings reveal that teachers mainly practised social constructivism and progressivism as educational philosophies to develop critical thinking skills in learners. Based on the findings, the authors conclude that developing critical thinking skills in secondary school learners by using relevant educational philosophies could result in preparing them for the future world of work or tertiary education. The implication from the findings and conclusion is that, to meet the demands of the 21st-century soft skills, critical thinking should no longer be an auxiliary goal but a main objective of the education system. As a recommendation to develop critical thinking in the secondary school learners, the Department of Education and policymakers should implement ongoing teachers' continuous professional development that involves hands-on strategies for teaching each subject in classrooms.

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Chapter # 18

THE USE OF GRADE-LEVEL READERS IN THE FOUNDATION PHASE

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ABSTRACT

Grade-Level Readers in the form of Reading Anthologies are provided in South African Foundation Phase classrooms (Grades 1 to 3) for home language learners to promote their reading interest and make teaching reading easier. However, evidence shows that teachers lack an understanding of teaching reading in line with methodologies prescribed in the curriculum. This study examines the effectiveness of Grade-Level Reading Anthologies in impacting reading instruction and promoting reading in the Foundation Phase. A qualitative case study underpinned by Tomlinson's theory of differentiation, Vygotsky's Zone of Proximal Development and Krashen's Input Hypothesis were used to collect and analyse data in six quintile 1 and 2 (categorised as the poorest) primary schools. Grade 3 reading lessons (with grade-level readers used as the main resource during group guided reading activities) were observed. Data from the lesson observations were analysed manually by using thematic analysis. Classroom observations revealed the teachers' lack of knowledge in teaching reading and their inability to cater for differences and diversity in the classroom. In view of these findings, it is recommended that teachers be provided support through coaching from relevant stakeholders so that they can teach reading cognisant of the differences existing in their classrooms.

Keywords: grade level readers, foundation phase, reading anthologies.

1. INTRODUCTION

To cater for diversity and multilingualism in the South African context, Grade-Level Reading Anthologies have been developed in all 11 official languages taught in the Foundation Phase (Grades 1 to 3) classroom. However, the outcomes of Progress in International Reading Literacy Study between 2006 and 2021 show that the percentage of Grade 4 learners who cannot read for meaning in any language declined from 87% (2006) to 82% (2011) and down to 78% (2016) but increased back to 81% (2021) (Department of Basic Education, 2023). Although there was an outbreak of COVID-19 which disrupted the entire education system worldwide, the history of a 5% and 4% decline in the previous year's suggests that even if the pandemic had not disrupted the normal teaching and learning process, the percentage of learners who cannot read for meaning would not have dropped below 70%. There are several reasons contributing to the current literacy crisis in South Africa, and this includes inter alia the teachers' lack of knowledge in implementing Differentiated Instruction (a strategy for accommodating various learning needs) in the classroom (de Jager, 2016; Onyishi & Sefotho, 2020; Phala & Hugo, 2025). For this reason, the Department of Basic Education is calling for more advanced training of teachers to improve reading literacy in primary schools.

Unlike single graded readers, Reading Anthologies are collections of different stories compiled at the appropriate level of learners. Recent empirical work both internationally and in South Africa suggests that Grade-Level Readers and structured guided-reading programmes can improve early reading outcomes but only when materials are used together with teacher training and structured routines (Van Der Mescht, 2023; Kitsili & Murray, 2024). Large South African evaluations of early-grade reading interventions and programme reviews show that providing high-quality texts must be combined with teacher support, assessment routines and clear guided-reading practice to produce measurable learning gains (Department of Basic Education, 2024). Research from smaller South African studies also highlights that teachers often lack the specific pedagogical knowledge to conduct group guided reading as intended. For example, Kitsili and Murray (2024) found gaps in teachers' knowledge of small-group organisation, text selection and formative monitoring during group guided reading in township Foundation Phase classrooms. International and classroom-level studies of graded readers further indicate mixed findings, highlighting that graded texts increase access and opportunity to read but can fail to match perceived reading difficulty unless teachers continuously match texts to learners and scaffold appropriately (Arai, 2022). Together, these findings underline a recurrent pattern, asserting that book provision alone is insufficient; it must be coupled with teacher professional learning, routines for assessment and explicit guided-reading practice (Zenex Foundation, 2019).

This study looked at the use of home language Grade-Level Reading Anthologies in the South African Foundation Phase classroom. Very little research (if any) has been done in terms of examining the use of Grade-Level Reading Anthologies in the Foundation Phase. Studies conducted to date focus on single graded readers (Seals, 2013; Spaull & Pretorius, 2019; Taylor, Cillier, Prinsloo, Fleisch & Reddy, 2019; Phekani, 2023). This study was an intervention which occurred in the form of providing isiZulu home language Reading Anthologies to a randomised sample of 100 Quintile 1 to 3 schools in the King Cetshwayo District in KwaZulu-Natal and teacher guidelines which were intended to help teachers use the anthologies effectively in their classrooms. To establish whether the provision of Reading Anthologies had implications for reading practices and whether they promoted reading in the classroom, an in-depth qualitative case study design was used to gather data in six quintile 1 and 2 schools. Hence, Grade 3 reading lessons (with the Reading Anthologies used as the main resource during group guided reading activities) were observed in the sampled schools.

For this study, the following research questions were posed: *What is the impact of Grade-Level Reading Anthologies on reading instruction? How effective are Grade-Level Reading Anthologies in promoting reading in the Foundation Phase classroom?* To answer these questions, the article first unpacks theoretical framework used to situate this study and discusses the literature related to this topic. This is followed by describing the method used to collect and analyse data. Finally, the main findings, implications and conclusions are presented.

1.1. Theoretical Underpinnings of Differentiated Literacy Instruction

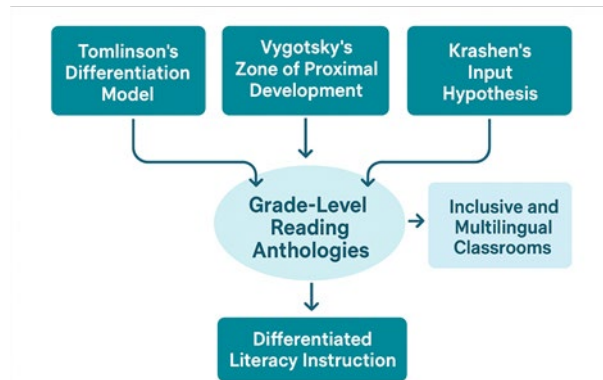
Tomlinson's (1999, 2003) Model of Differentiation underpins this study as it provides a comprehensive framework for understanding how teachers adapt content, process, and assessment to accommodate learner diversity. The model's relevance to Foundation Phase literacy teaching lies in its emphasis on aligning instructional strategies with learners' readiness, interests, and learning profiles. Tomlinson describes Differentiation as the process of factoring in learners' individual needs before designing a lesson plan, thereby enabling teachers to tailor instruction to accommodate differences and diversity in their classrooms.

Through this approach, all learners, regardless of linguistic background or reading ability, can engage meaningfully with literacy instruction.

Empirical evidence supports the effectiveness of Differentiated Instruction in improving literacy outcomes for both struggling and advanced learners. For instance, Magableh and Abdullah's (2020) quasi-experimental study involving Grades 4 and 5 English as a Foreign Language learners in Jordan revealed that learners exposed to differentiated instruction significantly outperformed those in the control group in reading comprehension. Similar findings by Alghamdi (2022) and Groenewald, Nkosi and van der Walt (2024) affirm that differentiation fosters inclusive participation and promotes equitable learning outcomes across varied contexts.

In multilingual and socioeconomically diverse South African classrooms, Differentiation is not only a pedagogical strategy but also an inclusive imperative. According to Kirschner (2015), inclusion refers to the integration of learners with physical, cognitive, linguistic, and behavioural differences into mainstream classrooms, ensuring their participation in meaningful learning experiences. An inclusive classroom thus requires teachers to implement differentiated approaches that meet the heterogeneous needs of all learners (Webster, 2014). Within the South African context, where teachers routinely navigate linguistic, cultural, and ability differences (Singh, 2004), the Curriculum and Assessment Policy Statement emphasises inclusion as a guiding principle for teaching and learning (Department of Basic Education, 2011). Such environments foster a sense of belonging and value among learners (Garibay, 2015). However, research indicates that many teachers still struggle to design instruction that effectively accommodates classroom diversity (Mahlo, 2017; Adewumi & Mosito, 2019; Omodan & Ige, 2021). For example, Omodan and Ige's (2021) study on managing diversity in South African high schools identified language, culture, and learning impairments as key challenges affecting inclusive classroom practices. Theoretically, this study is also grounded in Vygotsky's (1978) Zone of Proximal Development and Krashen's (1985) Input Hypothesis, both of which complement Tomlinson's model by explaining how learners progress through scaffolded and differentiated literacy support. Vygotsky's Zone of Proximal Development emphasises that learning occurs when tasks are slightly beyond the learner's independent level and supported through teacher or peer scaffolding. Similarly, Krashen's Input Hypothesis posits that language acquisition happens when learners receive *comprehensible input*, texts that are slightly above their current proficiency ($i + 1$), and are supported to make meaning from them. Below is a visual image showing how Tomlinson's Differentiation, Vygotsky's Zone of Proximal Development, and Krashen's Input Hypothesis converge in the Grade-Level Reading Anthologies framework.

Figure 1.
Tomlinson's Differentiation Model with sociocultural and language acquisition theories.



The Grade-Level Reading Anthologies operationalise these theoretical principles by providing graded, scaffolded reading materials that bridge learners' current and potential reading competence. In practice, this means that teachers can use Grade-Level Reading Anthologies to differentiate reading instruction, group learners according to reading ability, provide targeted scaffolding, and progressively advance learners through more complex texts. Thus, by integrating Tomlinson's Differentiation Model with sociocultural and language acquisition theories, this study situates the pedagogical use of Grade-Level Reading Anthologies within a robust theoretical framework that links differentiated instruction, inclusion, and literacy development in multilingual Foundation Phase classrooms.

1.2. Literature Review

This section explores literature relevant to the use of Grade-Level Reading Anthologies in the Foundation Phase classrooms. Academic databases such as JSTOR, EBSCOhost, and ERIC were used to locate relevant literature. The literature reviewed is conceptualised to provide a critical understanding of how Grade-Level Reading Anthologies contribute to reading development, scaffolding, comprehension, and addressing learner diversity in multilingual contexts. The discussion is grounded in sociocultural and language acquisition theories.

1.2.1. Grade-Level Reading Anthologies

Grade Level Reading Anthologies are collections of different stories compiled at the cognitive levels of learners from Grades 1 to 3. In the South African Foundation Phase classroom, each learner receives an anthology to use in class and at home to promote reading practice. As shown in Figure 2, these anthologies are differentiated by level and colour (blue for struggling readers, green for average readers, and red for advanced readers), enabling teachers to tailor reading instruction according to learners' abilities. They provide learners with opportunities to access a wide range of stories written in their home language.

Figure 2.
Reading Anthologies differentiated by level and colour.



Research highlights that age-appropriate, reading texts significantly enhances early literacy acquisition and reading fluency (Wang, 2021; Khair, Rafik-Galea, Yasin, Noor, & Armum, 2025). Although the Foundation Phase anthologies contain colourful pictures; they are paperbound (softcover) books which make it challenging to sustain them, given their fragility. An alternative to using softcover texts which are unsustainable, is to opt for eBooks. However, although eBooks are sustainable and useful in developing children's literacy skills better than print books (López-Escribano et al., 2021), digital access remains a challenge in under-resourced and historically disadvantaged schools (Moyo & Phiri, 2022). Therefore, printed anthologies remain essential tools for literacy development in such contexts, aligning with *Biblioneef's* (the programme theory of donor organisation) emphasis on access to culturally relevant and age-appropriate reading materials to foster literacy and learner confidence (Nassimbeni & Desmond, 2011). It is thus recommended, as per the Teacher's Guide, that teachers should teach learners to take good care of their Reading Anthologies for the purpose of sustaining them. *Biblioneef* further adds that access to books which are looked after and age-appropriate is beneficial (ibid).

1.2.2. Role of Grade-Level Reading Anthologies in the Foundation Phase

Grade-Level Reading Anthologies play a central role in developing learners' literacy in their home language, as they are available in all official South African languages used as the languages of learning and teaching in the Foundation Phase. Text conventions such as illustrations and pictures in these anthologies help learners comprehend texts better (Al Hinaai, 2021). This is supported by studies showing that texts accompanied by pictures can improve reading comprehension, particularly for learners with reading difficulties (Razalli, Thomas, Mamat & Yusuf, 2018; Parks, 2020). Accurate and contextually relevant illustrations therefore serve as important pedagogical aids that enhance learners' understanding and engagement with texts.

Another significant contribution of Grade-Level Reading Anthologies is their support for differentiated literacy practices. These anthologies enable teachers to implement a variety of reading activities such as group guided reading, paired reading, and independent reading (Department of Basic Education, 2020). Differentiated reading instruction according to proficiency level aligns with Tomlinson's (2003) Differentiation Model, which advocates tailoring content, process, and outcomes to learners' readiness, interests, and learning profiles. Empirical studies further confirm that Differentiated Instruction positively influences reading comprehension and learner motivation (Magableh & Abdullay, 2020; Alghamdi, 2022). In multilingual classrooms, where learners' home and school languages often differ, Grade-Level Reading Anthologies also serve as valuable tools for bridging linguistic and cognitive gaps. They allow learners to draw on their multilingual repertoires while developing proficiency in the language of learning and teaching, fostering both language acquisition and identity affirmation (Cummins, 2017; García & Wei, 2019). This makes them particularly relevant in the South African context, where multilingualism is both a linguistic reality and a policy goal.

Recent educational policies and curriculum frameworks have increasingly recognised the importance of Grade-Level Reading Anthologies and graded readers as tools to support differentiated and scaffolded reading development. In South Africa, for instance, the Curriculum and Assessment Policy Statement encourages the use of reading texts that correspond with learners' reading abilities and language proficiency levels (Department of Basic Education, 2011). This emphasis reflects a broader global shift toward inclusive and evidence-based literacy instruction that accommodates diverse learner needs (UNESCO, 2023). Grade-Level Reading Anthologies thus align with policy objectives promoting equity, access, and quality learning, as they provide level-appropriate materials that enhance reading fluency, comprehension, and motivation among early readers.

Finally, the effective pedagogical use of these anthologies depends largely on teachers' professional knowledge and ability to select and use appropriate materials. Well-trained teachers are better positioned to match texts to learners' developmental stages, scaffold comprehension, and integrate reading into broader literacy development goals (Pretorius & Spaull, 2016). Continuous professional development that focuses on reading pedagogy, assessment of reading levels, and material selection is therefore crucial. When teachers are empowered to make informed pedagogical choices, Grade-Level Reading Anthologies become powerful tools for promoting meaningful and sustained literacy growth among Foundation Phase learners.

1.2.3. Using Anthologies According to Foundation Phase Teacher's Guide

The Foundation Phase Teacher's Guide outlines the pedagogical use of Grade-Level Reading Anthologies according to structured reading activities such as group guided reading, paired reading, and independent reading (Department of Basic Education, 2020).

Group guided reading: At the beginning of the year, teachers conduct baseline assessments to establish learners' reading levels and group them according to ability. In line with the guidelines, learners are encouraged to take their Reading Anthologies home for reading practice with parental or caregiver support. The teacher monitors progress through an individual reading page for each learner, which helps determine when learners are ready to move to a different level. This process reflects Vygotsky's concept of scaffolding within the learner's Zone of Proximal Development, as learners receive guided support that gradually decreases as their competence increases.

Given the fragility of the texts, teachers are also expected to instil in learners a sense of responsibility in handling books both at home and in the classroom. During daily group guided reading sessions, the teacher typically works with two small groups of 6 to 10 learners for about 15 minutes each, using anthologies matched to their reading levels. The teacher listens carefully as learners read aloud, providing support and feedback where needed. Learners who progress quickly are advanced to higher levels, while those who need more time receive additional support before moving on.

Paired reading: Paired reading creates opportunities for collaborative learning where the teacher reads with a struggling learner, or learners take turns reading to each other. This practice fosters peer support and reinforces fluency and confidence, aligning with sociocultural learning theories that highlight collaboration as central to knowledge construction (Wood, Briner & Ross, 1976).

Independent reading: Independent reading allows learners to read the anthology on their own, either in class or at home, promoting autonomy and self-motivation. This practice echoes Krashen's (1985) principle of *free voluntary reading*, which posits that exposure to comprehensible and interesting texts naturally enhances language acquisition. Like paired reading, independent reading often takes place while the teacher is engaged with small reading groups.

The successful implementation of these reading activities depends largely on teachers' pedagogical competence and their ability to apply sound reading instruction principles. The *Teacher's Guide* provides a structured framework, but its effectiveness rests on teachers' understanding of how to select suitable materials, scaffold learning, and assess progress accurately. As Pretorius and Spaul (2016) argue, teachers who are well-trained in reading pedagogy are better equipped to match texts to learners' developmental levels and foster comprehension through guided support. Conversely, limited training can result in inappropriate text selection, mechanical reading practices, and minimal learner engagement. Therefore, continuous professional development focusing on reading pedagogy, formative assessment, and Differentiated Instruction is crucial. When teachers are empowered to implement the graded reading programme as intended, Reading Anthologies become powerful tools for developing learners' literacy, comprehension, and a lifelong love of reading.

Although existing studies affirm the value of graded readers in promoting literacy development, there remain limited research on how Grade-Level Reading Anthologies are implemented within differentiated literacy instruction in multilingual South African classrooms. Few studies have examined how teachers scaffold reading comprehension using graded materials in ways that align with sociocultural and language acquisition theories, or how inclusive and differentiated practices intersect in resource-constrained contexts. This study, therefore, seeks to address these gaps by exploring the pedagogical use of Grade-Level Reading Anthologies in Foundation Phase classrooms to enhance reading comprehension within differentiated and multilingual learning environments. Guided by the said aim, the next section describes the methodology used to collect and analyse classroom observation data.

2. RESEARCH METHODOLOGY

The reading anthologies were investigated through classroom observations to understand how teachers implemented and used them to support Differentiated literacy instruction in multilingual Foundation Phase classrooms. The study was conducted in six quintile 1 and 2 schools (4 Primary and 2 Combined Schools) selected from a randomised

sample of 100 quintile 1 to 3 schools in the King Cetshwayo District of KwaZulu-Natal. A qualitative case study design was used to observe one Grade 3 isiZulu home language lesson in each of the six schools. The Grade 3 class in each school was selected randomly and automatically included teachers of the targeted classes. Notes were taken throughout the research gathering process to supplement data captured through video and audio recordings during observations. A lesson observation instrument (*See Appendix A*) reflecting the realities and demands of the Foundation Phase curriculum and prepared by Zenlit Intervention (2016) was used to gather information about six home language reading lessons in the Grade 3 classrooms.

The lesson observation instrument was adapted to suit the focus of this study, and it is divided into two sections. **Section A** covers details of school visits. **Section B** comprises lesson observations, which looked at the following aspects: classroom teaching and learning environment, the use of reading anthologies in the classroom, group guided reading activities and opportunities afforded to learners to read in isiZulu home language. Only one Grade 3 classroom was observed per school, and all the teachers in each of the six schools volunteered to participate in the study. Observations in each classroom lasted approximately 10 to 30 minutes.

For the purpose of this study, the qualitative data from the observations were analysed manually by using thematic analysis, following Braun and Clarke's (2006) six-phase framework for doing qualitative thematic analysis. The first phase involved transcriptions and translations of lesson observations from isiZulu to English, ensuring familiarity with the data and identifying patterns in meaning across the data. The second phase involved generating initial codes from the data, moving back and forth. The third step involved sorting all potentially relevant coded data extracts into themes which were guided by the research questions posed for the study. In the fourth step, the coded data extracts for each theme were reviewed to check whether they formed a coherent pattern. The fifth step involved determining what aspects of the data were captured by each theme. The final sixth step involved the writing up of the report.

Ethical principles were considered in this study. The study was led by the Department of Basic Education in partnership with the Wits Consortium and entailed evaluating one of its programmes in public schools. Consent was obtained from all participants in the evaluation. Pseudonyms are used to protect the identity of the participants and schools (e.g., Grades 3 teachers are referred to as TA to TF, and schools as School A to School F). Having outlined the research methodology, it is now essential to turn to the analysis and interpretation of the data.

3. FINDINGS AND DISCUSSION

The findings from classroom observations are presented according to the following themes: classroom teaching and learning environments, the use of Grade-Level Reading Anthologies in the Foundation Phase classroom, group guided reading activities, Teacher's Guide and opportunities for reading in the home language.

3.1. Classroom Teaching and Learning Environments

Most classes observed were not creative print rich environments. Some classrooms had dull walls which did not display colourful learning charts or posters, as shown in Figure 1. Although all the six Grade 3 classrooms in the schools sampled had a classroom library corner, the classroom of the School B teacher (TB) was the only one where the Grade-Level Reading Anthologies were displayed on the library bookshelves. The visibility of single readers in the classroom of Schools A and E suggested that teachers and learners were not effectively using the anthologies provided to promote reading. Thus, although teachers received the Reading Anthologies, it seemed as if some used them superficially, suggesting that they preferred the single readers to the Reading Anthologies provided. In the classroom of School C, there was no evidence that TC used the anthologies with learners in her classroom. All the Reading Anthologies in the classrooms observed did not seem to have been covered to sustain their use, suggesting that they were not taken care of. Three classrooms (Schools A, B and E) had a library corner, but the classroom in School B seemed to be the only one with an organised library corner, and the anthologies displayed on the bookshelves in School B were still in good condition compared to other classes. Each learner received a copy of the reading anthology in the classroom of Schools A, B and D, whereas in the classroom of Schools E and F, learners either shared the book in pairs or in groups. In the classroom of School C, there was no sign showing that the teacher and her learners used reading anthologies.

3.2. The Use of Grade Level Reading Anthologies in the Classroom

Grade-Level Reading Anthologies in all the classes observed were used for group guided reading, reading aloud, or choral reading in groups or as the whole class. Paired/independent reading was only done in the classroom of TA. Children in her class were called up to read to the whole class during the group guided reading slot while the other learners listened. Only TB used the anthologies according to the learners' level of reading development (as shown in Figure 2), given that the books catered for various reading developments. For example, in School B, the Grade 3 teacher (TB) allocated Reading Anthology 3 to the group of fluent readers and Reading Anthology 1 to a second group of struggling Grade 3 readers, which is a clear practice of level-matching that aligns with the Teacher's Guide. By contrast, in five other classrooms the same Grade-Level Reading Anthology (Anthology 3) was used for the whole class regardless of reading level. These contrasting cases from the six observed classrooms provide concrete, case-based evidence that while the resource (anthologies) can support differentiated practice, teacher enactment varies widely.

Figure 3.
Grade 3 Group Guided Reading activities in School B classroom.



3.3. Group Guided Reading Activities

Group guided reading lesson activities where teachers used the anthologies were observed in all six Grade 3 classrooms in each school. According to the South African National curriculum, teachers should see two small groups daily (each for 15 minutes). However, from what was observed, two Grade 3 teachers in Schools A and B were the only ones who managed to see two groups for about 15 minutes each as per the recommendations in the curriculum. However, Schools C, D, E and F spent less than 12 minutes with a small group or the whole class. Although it was group guided reading time, all the teacher's engaged learners on choral reading (reading aloud with the whole class or groups). This defeats the purpose of group guided reading, which is intended for differentiated teaching, where teachers get to listen to learners reading individually in each group. Although research has shown that choral reading, when used as one of many reading activities, can positively influence reading fluency and comprehension (Kodan & Akyol, 2018), whole class or group chorusing can be misleading because it creates the impression that everyone is reading, it does not provide teachers with opportunities to observe individual reading behaviours and identify areas that need attention. Some teachers did not organise activities to engage the other groups when they were busy with their ability groups, so the rest of the class played and made noise.

During a 15-minute group guided reading lesson in School B, TB split the class into two small groups. The first group of six readers (identified by TB as 'fluency readers') read from Reading Anthology 3 independently while TB listened and made short running notes; the second group of six received Reading Anthology 1 and TB scaffolded decoding and vocabulary (predicting, picture cues and echo reading). As a result, TB was able to observe individual miscues and give targeted prompts, which is consistent with Tomlinson's readiness principle and Vygotskian scaffolding. In School C, by contrast, the teacher (TC) used anthology 3 for the entire class and led choral reading for 10 minutes; there was no small group listening or individual reading records. These two classroom cases illustrate how the same resource (Reading Anthology) can either be enacted in a differentiated, scaffolding

manner or used in a superficial, whole-class way, producing very different instructional affordances for struggling readers.

According to the initial planning, teachers knew in advance that there would be observations so that they could prepare their reading lessons; however, none of the teachers produced evidence that they were prepared for their group guided reading lessons, suggesting that what was observed seemed to be a true reflection of what is usually happening in most Foundation Phase classrooms, which is not in line with what is recommended in the curriculum policy document. This also suggests that teachers did not plan beforehand because they do not know how to organise and plan for teaching that accommodates diversity (Mahlo, 2017; Adewumi & Mosito, 2019; Omodan & Ige, 2021).

3.4. Opportunities for Reading in the Home Language

Although teachers had challenges conducting group guided reading activities according to what is stipulated in the curriculum, it was intriguing to note that in most classrooms (except School C) observed, they used the anthologies provided to conduct a choral reading with learners. For example, in the classroom of School A, choral reading was done during group guided reading in pairs/independently and in groups, as shown in Figure 4 below. This seems to have increased the amount of time spent reading in the learners' isiZulu home language during school time.

Figure 4.
Group Guided Reading Activities in School A Classroom.



3.5. Teacher's Guide

The provision of Reading Anthologies in KwaZulu-Natal schools included the Teacher's Guide to help teachers use the anthologies in line with what is recommended. However, from what was noted during observations, there was no evidence showing that teachers used the guide to support teaching and learning in their classrooms. This was supported by the fact that neither of the teachers had a reading record to note the reading progress of the learners as recommended in the guide and neither did they seem to understand how to conduct group guided reading.

4. IMPLICATIONS OF FINDINGS

This section presents implications relating to the following findings: classroom environment that supports reading, the use of Grade-Level Reading Anthologies, and lack of knowledge to conduct group guided reading.

Classroom environment that supports reading: Findings revealed that most classrooms were not print-rich environments; they lacked creative reading corners. These deprived learners of the opportunity to easily access a range of reading texts or to read them for enjoyment.

The Reading Anthologies in all the classrooms observed did not seem to have been covered to sustain their use. Given that soft covers are used on these books, it is likely that they may get torn easily and lose pages if they are not taken care of. Therefore, learners may not enjoy reading books which have incomplete pages.

The use of Grade-Level Reading Anthologies: Reading Anthologies provide teachers with opportunities to use the texts according to the learners' reading level. However, findings showed that most teachers gave all the learners the same reading anthologies, suggesting that they do not have the knowledge to accommodate differences and diversity in their classrooms. According to Tomlinson (2003), struggling learners require additional support to foster their understanding and fill in knowledge gaps. These findings have negative implications for struggling learners who are unlikely to be afforded individual learning support and may rarely catch up with their peers.

Lack of knowledge to conduct group guided reading activities: Findings also revealed that most teachers did not seem to have acquired sufficient knowledge and skills in conducting group guided reading. This was in spite of the provision of the Teacher's Guide which was meant to help teachers use the anthologies for teaching reading according to what is prescribed which raises the question of whether the Teacher's Guide was worthwhile. Given the importance of these activities in providing teachers with opportunities to implement differentiation, this suggests that the 'one size fits all' approach prevails at the disadvantage of struggling learners who need extra support.

In view of the findings in this study, it is evident that reading challenges in the South African classroom are not necessarily about the shortage of reading material because the Department of Basic Education strives to ensure that each learner has a copy of a text to read in the classroom and at home. As mentioned earlier, this could be about the teachers' lack of knowledge in teaching reading according to the methodologies recommended in the curriculum in terms of implementing Differentiated Instruction (de Jager, 2016; Onyishi & Sefotho, 2020). These cases mirror findings from recent South African evaluations and programme reviews, which revealed that book provision increases opportunities to read but does not automatically translate into Differentiated Instruction or improved outcomes unless teachers receive targeted professional development and routines for group organisation, text selection, formative monitoring and record-keeping (Zenex Foundation, 2021; Department of Basic Education, 2024). Consequently, scaled book distribution should be accompanied by systematic in-service coaching, simple assessment tools (reading records) and follow-up classroom support, an approach supported by programme evaluations and Non-Government Organisation practice in South Africa.

5. LIMITATIONS

Data collected in this study was not without limitations. According to the initial planning, teachers knew in advance that there would be observations so they could prepare lessons. However, none of the teachers observed had a lesson plan for their reading lesson. This suggested that what was observed seemed to be a true reflection of what usually happens in the classroom, which is not in accordance with the recommendations in the Teacher's Guide.

6. CONCLUSION

The purpose of this study was to examine the use of Grade-Level Reading Anthologies and how they can be sustained in the Foundation Phase classroom and at home. Based on the analysis conducted, it can be concluded that the provision of anthologies in the King Cetshwayo District in KwaZulu-Natal seemed to have increased opportunities for the learners' home language reading in the Foundation Phase classroom. Teachers also generally expressed relief that they had graded resources for use in the classroom. However, it limited the use of the Reading Anthologies in that teachers used them without following what was prescribed in the guidelines.

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Chapter # 19

THROUGH A CHILD'S EYES

Literature as a bridge to understanding PTSD

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ABSTRACT

This article examines a corpus of Israeli picture books for children aged 4–7 that depict fathers coping with combat-related posttraumatic stress disorder (PTSD). Written and published in direct response to the October 7, 2023 attacks and the ensuing Iron Swords War, these six works constitute the only literary corpus to date that addresses paternal combat-related PTSD in Israeli children's literature. They mark a profound cultural shift, challenging established motifs of heroism and sacrifice alongside the broader national ethos that has long shaped Israeli narratives for the young. The analysis considers these six books: *Papa Tank* (Sosonovsky, 2023), *Posti and Me* (Leibovitz & Cohen-Leibovitz, 2025), *What Happened to Or's Dad?* (Brosh, 2024), *Where Did Dad's Laughter Go?* (Tzvi, 2024), *Daddy Postamaty* (Zerach, 2024), and *Menachem's Secret Soldier* (Ramati, 2024). Together, these books trace how trauma reshapes family life - from initial harmony through paternal withdrawal and children's emotional disorientation to tentative understanding and open-ended recognition. By translating complex psychological realities into symbolic and accessible forms, the corpus enables young readers to perceive war and recovery through a child's eyes, foregrounding young children's emotional interpretations and coping strategies. These works reconfigure the canonical figure of the stoic "Israeli fighter," redefining heroism to include vulnerability, empathy, and relational resilience. Beyond the Israeli context, the study contributes to broader academic and pedagogical discourse on trauma, illustrating how children's literature can serve as a cross-cultural and therapeutic medium that equips young readers, especially those growing up amid conflict, with tools for dialogue, emotional literacy, and resilience.

Keywords: picture books, paternal PTSD, children's literature, pedagogy of war, trauma narratives, child perspective.

1. INTRODUCTION

When children grow up amidst wars and political conflicts, children's literature is inevitably called upon to mediate experiences of trauma. Israeli children's literature (hereafter: "the literature") is no exception; from its inception in the early twentieth century, it was compelled to grapple with the fears, losses, and devastation generated by the Arab-Israeli conflict, while reflecting the prevailing sociocultural ideologies and norms in which it was produced.

While the literature has long addressed themes of war, bereavement, and national ethos, the aftermath of October 7, 2023, and the ensuing Iron Swords War generated a literary development without precedent: the publication of six picture books for early childhood that directly confront paternal combat-related PTSD. These works - *Papa Tank* (Sosonovsky, 2023), *Posti and Me* (Leibovitz & Cohen-Leibovitz, 2025), *What Happened to Or's Dad?* (Brosh, 2024), *Where Did Dad's Laughter Go?* (Tzvi, 2024), *Daddy Postamaty* (Zerach, 2024), and *Menachem's Secret Soldier* (Ramati, 2024) - constitute the only existing corpus in Israeli children's literature to explicitly represent paternal combat-related PTSD for

readers aged 4–7. Earlier works occasionally alluded to the psychological toll of war, but none depicted post-trauma directly; the emergence of this corpus thus marks a significant cultural and literary shift.

The publication of these works also signals a broader cultural transformation. By depicting fathers who struggle emotionally, withdraw, seek help, and articulate vulnerability, the books challenge the long-standing ideal of the stoic, emotionally restrained "Israeli fighter." They introduce a reconfigured model of heroism grounded in emotional honesty, relational responsibility, and the courage to confront invisible wounds. In doing so, the corpus expands the representational boundaries of Israeli children's literature and reshapes the cultural imagination surrounding fatherhood in times of war.

This article examines how these six picture books reflect and reshape cultural understandings of paternal trauma in contemporary Israel. It analyzes the narrative, visual, and symbolic strategies through which the texts present PTSD to young children and explores how these representations mediate fear, empathy, and resilience within families. By situating the corpus within historical, psychological, and literary contexts, the study demonstrates how children's literature has become a key site for negotiating the emotional and ethical challenges of life in a war-torn society.

2. BACKGROUND

On Saturday morning, October 7, 2023, at 6:32 a.m., Hamas and Islamic Jihad launched a coordinated surprise attack on Israel, targeting both civilian communities and IDF bases through a combination of artillery fire and ground infiltration. The assault involved widespread atrocities, resulting in the deaths of 1,163 people, including 38 children, and the abduction of 255 individuals, among them 42 children. At 10:26 a.m., the IDF spokesperson announced the launch of Operation Iron Swords, soon followed by a northern front opened by Hezbollah. What began as a military operation rapidly evolved into the prolonged Iron Swords War.

Between October 2023 and November 2025, approximately 143,000 civilians were evacuated from the Gaza envelope and 68,500 from northern Israel. Over this period, more than 37,500 rockets, missiles, and UAVs were launched into Israeli territory, generating over 59,600 alerts that repeatedly sent civilians into shelters (INSS, 2025). Calls to ERAN, Israel's national emotional first-aid hotline, surpassed half a million, with many callers describing their experience as a "pressure cooker", a metaphor for the cumulative strain of prolonged uncertainty and danger (ERAN, 2025).

The psychological toll on soldiers and reservists has been profound. Fourteen months into the war, more than 6,400 applications for psychiatric disability had been submitted to the Ministry of Defense's Rehabilitation Department, nearly half filed by reservists (Israeli Knesset Research Center, 2025). By August 2024, over 10,000 wounded soldiers had been registered, 35% of whom were coping with psychological conditions. Studies by the National Center for Traumatic Stress and Resilience at Tel Aviv University indicate that 12% of reservists who fought in Gaza reported severe post-traumatic symptoms - a 50% increase from prewar levels. Rising numbers of suicides among active and reserve soldiers further underscore the depth of the crisis (Bar-Haim, 2025; Israel Association of Public Health Physicians, 2025). Importantly, these psychological effects rarely remain confined to the soldiers themselves; emerging research demonstrates that parental trauma can have measurable emotional and behavioral consequences for children as young as preschool age (Allbaugh et al., 2024; Watson & Osborne, 2025).

To understand the significance of the recent literary corpus, these present-day realities must be understood within Israel's broader historical trajectory of recognizing and representing trauma. During the War of Independence (1947–49), wartime psychological injuries were poorly conceptualized and frequently stigmatized. Soldiers displaying signs of distress were dismissed as weak or morally lacking. This approach persisted through subsequent conflicts, including the Sinai Campaign (1956) and the Six-Day War (1967), when rapid military victories left little space for acknowledging psychological suffering.

The Kippur War (1973) marked a turning point. The scale of casualties and the disillusionment that followed catalyzed the establishment of mental health centers and formal recognition of combat-related trauma. Yet, many veterans remained untreated, and societal stigma endured throughout later conflicts - the Lebanon Wars, the Intifadas (Palestinian Uprisings), and military operations in Gaza. Over time, trauma gradually shifted from a hidden personal wound to a recognized cultural phenomenon, reshaping public discourse and opening new spaces for literary engagement (Alberstein, Davidovitch., & Zalashik, 2016; Bilu & Witztum, 2000; Keynan, 2012).

Israeli children's literature developed in parallel with these societal transformations. Until the 1970s, shaped by Zionist ideology, it emphasized national ethos, self-sacrifice, agricultural labor and collective belonging. Psychological vulnerability - particularly that of soldiers - was largely absent. The Kippur War destabilized this heroic paradigm and introduced more emotionally complex portrayals of loss and fear. Works such as Tirza Atar's *War Is a Crying Thing* (1975) and Uri Orlev's *The Beast of Darkness* (1976) expanded the boundaries of children's literature by acknowledging the child's emotional world and offering literary spaces for coping with anxiety and grief. Yet these books remained exceptions, and the dominant literary ethos continued to marginalize depictions of psychological struggle. For decades, the literature continued to privilege resilience, patriotism, and heroic masculinity, leaving post-trauma notably unaddressed (Nasie, Bar-Tal, & Diamond, 2017; Dori, 2024).

As the conflict became chronic, a bibliotherapeutic orientation emerged. Recent empirical research demonstrates that parental trauma has measurable emotional and behavioral effects on young children (Allbaugh et al., 2024). Children's literature increasingly functioned as a tool for emotional support, offering symbolic frameworks for coping with parental absence, uncertainty, and fear. This developmental function aligns with foundational insights from Piaget (1962) and Vygotsky (1978), both of whom emphasize that young children rely on symbolic representation, narrative structures, and guided meaning-making to process complex emotional experiences. Recent qualitative research further indicates that when parents - particularly fathers - experience combat-related PTSD, the entire family system becomes destabilized, reshaping parenting practices and increasing children's emotional burden (Sturgeon, 2023). Yet despite these growing insights, one subject remained almost entirely absent from Israeli children's literature: the posttraumatic father.

The new corpus of picture books published after October 7 breaks this silence. By depicting paternal combat-related PTSD for the first time, these works constitute a significant cultural and literary shift. They not only acknowledge the psychological costs of war but also brings them into the intimate sphere of early childhood reading, where children encounter trauma through imagery, metaphor, and guided dialogue.

While the focus of this study is the Israeli corpus, it is important to acknowledge the wider human context. The Iron Swords War has had devastating consequences for Palestinian civilians in Gaza, including loss of life, displacement, and severe psychological and educational disruption. Recognizing this broader frame does not conflate distinct experiences

but underscores that the representation of Israeli paternal trauma is situated within a violent and protracted conflict whose impact extends across borders and communities.

3. PATERNAL COMBAT TRAUMA: FIVE NARRATIVE STAGES

The six picture books published in the aftermath of October 7, 2023, and the Iron Swords War construct a shared narrative arc that traces how paternal PTSD is experienced through the child's eyes. Each work depicts a cyclical rather than linear process: rupture, confusion, attempts at meaning-making, and moments of partial recognition. Taken together, they offer early childhood readers a symbolic vocabulary for understanding the invisible wounds of war.

3.1. First Stage: Idealized Family Life

Each story opens with a warm, harmonious family scene that establishes the father as loving, stable, and emotionally available. These idealized depictions - Or's father telling bedtime stories in *What Happened to Or's Dad?* (Brosh, 2024) or the "superhuman" father in *Daddy Postamaty* (Zerach, 2024) - create a clear emotional baseline against which the later rupture becomes legible to children.

Rather than serving merely as exposition, these scenes function as anchors of memory for the child protagonists. They mark the "before," providing the contrast necessary for children to interpret the dramatic changes that follow. The idealized father is not only a literary figure but also a cognitive and emotional reference point that stabilizes the child's internal world.

3.2. Second Stage: Withdrawal and Crisis of Fatherhood

Upon returning from war, the fathers exhibit emotional withdrawal, irritability, and sensory sensitivity, classic symptoms of PTSD (American Psychiatric Association, 2013), translated into child-accessible terms. Nir's father "never smiles ... always stares far away" in *Where Did Dad's Laughter Go?* (Tzvi, 2024), while Or observes that his father "barely talks, doesn't laugh, and doesn't hug" (Brosh, 2024).

These depictions articulate a crisis of fatherhood: the paternal figure, once a source of safety, becomes unpredictable or frightening. The father's self-perception as inadequate or dangerous is poignantly expressed in Zerach's *Daddy Postamaty* (2024), where the father describes himself as harboring a "volcano inside." Leibovitz's personal testimony in *Hagesher-Podcasts*,⁷⁵ (Leibovitz, 2025) further amplifies this sense of internal fragmentation. Parenthood is perceived as a failure, prompting physical and emotional distancing - understood by the fathers both as self-preservation and as a protective gesture toward the child.

Importantly, this withdrawal affects not only the dyad of father and child but also the entire family system. Several texts subtly foreground the mother's stabilizing role at this early stage, signaling that she will later serve as a bridge between the father's trauma and the child's need for explanation.

3.3. Third Stage: The Child's Struggle for Understanding

Trauma radiates outward, transforming the home from a stable and secure space into one marked by silence and tension. Rather than shifting the narrative focus, this silence intensifies the child's voice. Told through the child's perspective, the impact of paternal PTSD is rendered most vividly, allowing readers to perceive both the father's rupture and the child's

emotional and cognitive responses within the family. Because the father's injury is invisible, children struggle to grasp the source of this disruption. Nir's question - why his father no longer laughs - captures a central cognitive challenge for young children: interpreting a parent's invisible emotional distress, a difficulty well documented in developmental research on children's perception of parental emotions (May et al., 2023).

Children attempt to make sense of the rupture through observation, comparison, and metaphor (Piaget, 1962; Vygotsky, 1978). Or's question - "How can he be hurt if he didn't lose a leg, an arm, or even a finger?" (Brosh, 2024) - highlights the developmental difficulty of understanding psychological injury when it lacks external signs.

This stage foregrounds children's emotional ambivalence: fear mingles with longing; confusion with loyalty. The books do not resolve this tension; instead, they present it as an authentic component of the child's inner world when a parent's emotional landscape becomes unpredictable and unstable.

3.4. Fourth Stage: Children as Meaning-Makers

As the narrative focus shifts, children become active interpreters. They ask questions, experiment with metaphors, and engage in imaginative forms of symbolic play, mechanisms that developmental psychology identifies as crucial for processing trauma.

The most striking example appears in *Papa Tank* (Sosonovsky, 2023), where Yuval transforms his father's frightening anger into a dream-image of a tank wandering through the family kitchen. The metaphor evolves visually from a threatening machine to a gentle presence at the beach, mirroring the child's and father's gradual reorientation toward one another. The phallic imagery of the cannon shifting from erect to lowered subtly signals the father's transition from combat mode to vulnerability, but it is presented in a symbol system recognizable to young readers.

Across these texts, metaphor-making functions as a shared semiotic resource through which families articulate emotions that resist direct expression. The child's interpretations are not incidental responses but deliberate meaning-making processes that facilitate communication, relational attunement, and gradual emotional integration.

3.5. Fifth Stage: Open-Ended Recognition

In the final stage, the father's trauma becomes speakable, named, and shared, marking a shift from silent suffering to partial acknowledgment. Conversations, metaphors, temporary withdrawal, therapy, and community support emerge as coping strategies - each depicted as imperfect but meaningful steps toward stability. Across the corpus, these texts normalize psychological treatment, framing therapy as an act of responsibility and courage rather than a source of shame. By integrating therapeutic language into picture books, the works provide young readers with an accessible vocabulary for understanding emotional pain.

The climactic scenes in *Papa Tank* (Sosonovsky, 2023) and *Where Did Dad's Laughter Go?* (Tzvi, 2024) portray relational repair through subtle yet consequential interactions. The exchange: "Even when I'm angry, I always love you" (the father) / "I know" (the son), exemplifies the coexistence of rupture and affection, underscoring that parental love endures despite emotional volatility. Likewise, *Daddy Postamaty* (Zerah, 2024) demonstrates how symbolic metaphors - storms, volcanoes, popcorn kernels - translate the father's internal turmoil into forms accessible to young children, thereby bridging the gap between psychological complexity and early childhood cognition.

The final stage does not present trauma as resolved. Instead, these texts offer open-ended recognition, aligning with contemporary trauma theory that views healing as cyclical, relational, and ongoing. PTSD becomes integrated - not erased - within family life.

The emphasis on shared narratives, mutual reassurance, and community support (neighbors, teachers, extended family) signals that recovery requires collective engagement, not individual stoicism.

4. THE MATERNAL ANCHOR

While therapy and community support provide external frameworks for healing, the primary burden of emotional care within the home often falls on the family and particularly on the mother. Combat-related trauma disrupts not only the bond between father and child but also reconfigures the maternal role. Across the corpus, the mother emerges as a stabilizing presence who mediates between the traumatized father and the rest of the household. She is responsible for maintaining daily continuity, containing distress, and offering developmentally appropriate explanations of the father's condition, tasks that require her to balance acknowledgment of psychological pain with the preservation of emotional security.

In *Papa Tank* (Sosonovsky, 2023), the mother mitigates the child's fear following the father's outburst by explaining, "Sometimes it's very hard for Dad to remember things from the past ... but he loves you very much." By distinguishing between the father's behavior and his enduring affection, she enables the child to sustain attachment despite instability. Similarly, in *Daddy Postamaty* (Zerach, 2024), the mother addresses her partner with a combination of tenderness and clarity: "My love, I feel that things are very difficult for you ... yesterday, when you heard the children playing, you woke up shouting. Maybe you're post-traumatic?" Spoken within a physical embrace, her words communicate recognition, care, and a commitment to shared coping.

The mother-child relationship is likewise central. Mothers serve not only as interpreters of the father's trauma but also as emotional regulators for their children. Through reassurance, physical closeness, and clear explanations, they help children navigate fear and uncertainty, modeling adaptive emotional responses and reinforcing a sense of safety within the home. These interactions underscore the mother's dual role: supporting the traumatized parent while simultaneously safeguarding the child's emotional world.

By mediating communication, sustaining routine, and providing emotional containment, the maternal figure becomes a literary and cultural symbol of resilience. The narratives suggest that the family's capacity to endure trauma rests not on the erasure of suffering but on the shared labor of bearing it together - a labor in which the mother plays a central and often unacknowledged role.

5. FROM HEROIC SILENCE TO VULNERABLE HEROISM

The picture books analyzed in this study foreground the emotional and familial dimensions of PTSD while simultaneously functioning as cultural texts that critique and revise the foundational ethos of Israeli masculinity. Drawing on hegemonic masculinity theory (Connell & Messerschmidt, 2005), this section conceptualizes Israeli masculine ideals as culturally constructed hierarchies rooted in emotional restraint, militarized competence, and heroic silence. For decades, Israeli identity has been shaped by the figure of the stoic, self-disciplined "Israeli fighter," whose capacity to endure hardship privately aligns with what Connell (2005) identifies as "hegemonic masculinity." This model has long dominated Israeli literature, collective memory, and public discourse, reinforcing expectations that men absorb suffering without visible vulnerability.

The picture books at the center of this analysis mark a significant narrative departure. Rather than presenting PTSD as a failure of the heroic ideal, they situate trauma as an inherent, perhaps unavoidable, dimension of military service, thereby challenging the myth of invulnerability embedded within Zionist masculinity. In each narrative, the father initially appears strong, loving, and competent; yet the aftereffects of war destabilize this image. His transformation, from engaged parent to withdrawn, irritable, or frightening figure, exposes the tension between external performances of masculinity and the internal reality of psychological injury.

Importantly, these works do not reject the warrior ethos outright. Instead, they reinterpret heroism in ways that resonate with Butler's (2016) theorization of vulnerability as a relational and political condition rather than a private deficiency. Within this framework, heroism is reimagined as the willingness to confront pain, to remain emotionally available to one's children, and to seek therapeutic support when needed. Emotional endurance, relational responsibility, and the articulation of suffering emerge as indicators of strength rather than weakness.

This redefinition produces a broader, more flexible model of masculinity, one that integrates traditional narratives of patriotism and sacrifice with acknowledgment of fragility, dependency, and emotional expressivity. The traumatized father is not depicted as diminished; rather, his efforts to reconnect with his child, articulate his inner turmoil, and strive toward repair exemplify what trauma scholars describe as "everyday heroism" - the small, sustained acts of emotional labor that enable families to function in the aftermath of war (Caruth, 1996; Herman, 1992).

Significantly, this revised ideal does not obscure the child's emotional reality. Children continue to experience fear, longing, confusion, and ambivalence. These coexisting emotions reflect Winnicott's (1971) insight that early emotional life is shaped by the capacity to hold multiple, sometimes contradictory truths at once. The father can be loved and feared, admired and grieved, present yet psychologically distant. Through symbolic devices such as the living tank, the invisible wound, the imaginary companion, or the "secret soldier" - the books provide children with narrative scaffolding that helps them navigate these complexities without collapsing into denial or despair.

By presenting strength and pain as intertwined, these works offer young readers a new lexicon for understanding masculinity, one that honors the father's struggle while legitimizing the child's emotional world. In doing so, they transform the figure of the traumatized father into an emblem of quiet and relational heroism and contribute to a broader cultural reimagining of what it means to be a soldier, a man, and a parent in contemporary Israel.

6. CONCLUSION

The six picture books published in the aftermath of the October 7, 2023 attacks constitute the first sustained literary attempt to represent paternal combat-related PTSD for young children in Israel. As this study has demonstrated, these works collectively reshape the emotional, cultural, and pedagogical landscape of contemporary Israeli children's literature. By centering the child's perspective, they render trauma legible through accessible metaphors, visual symbolism, and narrative gaps that invite young readers to construct meaning from rupture. In doing so, the corpus establishes a literary grammar through which early childhood can begin to comprehend the impact of paternal post-trauma.

Across the texts, paternal combat-related PTSD is represented not as an isolated individual condition but as a relational and family-wide experience. The five-stage narrative pattern identified in this study - harmony, withdrawal, confusion, meaning-making, and open-ended recognition - reveals a shared cultural logic through which trauma is framed for young readers. These stories challenge earlier Zionist paradigms that equated heroism with silence and emotional self-containment. Instead, they promote a revised model of heroism grounded in vulnerability, relational responsibility, and the courage to confront psychological injury. In this reframing, the traumatized father emerges as a complex figure negotiating the intertwined demands of love, fear, and recovery.

Equally significant is the emergence of the mother as mediator and stabilizing anchor. The books portray mothers as the emotional and communicative bridge between the wounded father and the child, sustaining family life, interpreting behavioral shifts, and preventing children from internalizing blame or fear. This maternal role underscores the fundamentally relational nature of trauma recovery and deepens our understanding of family dynamics within wartime narratives for young children.

Notably, none of the works offer full resolution or cure. Instead, they depict PTSD as an ongoing, adaptive process that families navigate together. This mirrors contemporary trauma theory, which conceptualizes recovery not as linear improvement but as cyclical processes of rupture, repair, and reintegration. The open endings of these narratives allow children to hold multiple, often conflicting emotions such as love and fear, pride and sadness—without imposing closure that real life cannot guarantee.

Although grounded in Israeli experience, the corpus resonates with global contexts in which children witness or inherit war-related trauma. As such, it offers a framework for comparative analyses of children's war literature in other conflict zones and invites further interdisciplinary research at the intersections of literature, psychology, and education. Acknowledging the profound suffering experienced by Palestinian children and families situates these texts within a broader humanitarian landscape, reminding readers that literary representations of trauma always unfold within asymmetrical and shared contexts of violence.

Ultimately, this corpus demonstrates the capacity of children's literature to function simultaneously as a cultural mirror and a therapeutic tool. By translating paternal trauma into symbolic forms accessible to early childhood, these books create space for dialogue, empathy, and emotional literacy at a moment of acute national upheaval. In doing so, they contribute not only to Israeli literary history but also to the broader international conversation on how societies narrate war, vulnerability, and resilience to their youngest members.

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Chapter # 20

EXPLORING THE EFFECTIVENESS OF INTEGRATING DIDACTIC GAMES IN ARITHMETIC LESSONS: A case study at the rudimentary level in South Africa

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ABSTRACT

Primary school learners' consistent underperformance in arithmetic, mainly attributed to ineffective instructional approaches employed in mathematics classrooms in South Africa, is the impetus for conducting this study. This quantitative case study examined the efficacy of incorporating a didactic game - Magic Square - in tandem with the Gurteen Knowledge Café approach for arithmetic instructions. Participants (n = 31) were Grade 3 learners from a primary school in the Northern Cape Province. Initially, learners were taught arithmetic using the traditional approach, followed by a pre-test. The intervention involved collaborative groups of 3-4 learners engaging with the new pedagogy, followed by a post-test. Kolb's experiential learning cycle served as the theoretical framework. Data collection methods included classroom observations, a pre-test and a post-test. Learners' pre-test and post-test scores were statistically analysed using the Bayesian Random-Effect Negative Binomial Model, which revealed a significant difference between the mean marks of the pre-test and post-test. The findings suggest that Magic Square is a more effective pedagogical tool for conducting arithmetic lessons at a rudimentary level compared to the traditional approach. Consequently, the researchers recommend incorporating the Magic Square as a didactic game into arithmetic instructions in South African primary schools to improve learners' performance and engagements.

Keywords: arithmetic, didactic games, experiential learning, magic square, rudimentary level.

1. INTRODUCTION

Arithmetic is a fundamental mathematical concept taught at the rudimentary level. However, learners' persistent underperformance in arithmetic operations and properties has intensified scrutiny on how those concepts are taught in mathematics classrooms (DoBE, 2024). The limitations of abstract instruction via traditional methods have prompted a shift toward practical approaches, notably through the integration of didactic games in early arithmetic lessons (Vankúš, 2021; Rabbimov, 2020).

Gamification has emerged as an effective pedagogical strategy for primary mathematics, grounded in the premise that children learn best through thoughtful play, making lessons demonstrable, engaging and enjoyable (Liu, Wang, & Lee, 2021; Vankúš, 2021). Didactic games promote learning through play-based activities that foster social interaction, motivation and healthy competition (Zhelal & Kaymak, 2023). Rooted in progressivist epistemology, these games bridge the gap between abstract theory and practical understanding (Hui & Mahmud, 2023). Games like Magic Square make mathematics playful and joyful, enhancing learners' interest and motivating them to solve both familiar and novel problems.

Incorporating appropriate didactic games and scaffolded activities can enable learners to attain conceptual understanding. These games can be implemented individually or in groups. Vankúš (2013) identifies key components of effective game-based instructions: game environment, objectives, rules and assessment. Didactic games deepen conceptual understanding; they also enhance engagement, teamwork and critical thinking. They cultivate spatial reasoning, improve mathematical achievement, and support sensory-motor development (Zhelal & Kaymak, 2023). Examples include Math Bingo, Math Jeopardy, Domino, Snakes and Ladders, and Magic Square-the focus of this study. Incorporating didactic games involves creative, play-based activities, often competitive, that stimulate learners' interest and motivation (Zhelal & Kaymak, 2023). However, relevant didactic games must be carefully selected to align with specific mathematical concepts, and their incorporated lessons have to be delivered in an enabling environment.

This study tested the effectiveness of Magic Square for teaching Grade 3 learners' arithmetic. A Bayesian Random-Effect Negative Binomial Model was used to analyze participants' pre- and post-test scores. This statistical method of evaluating the effectiveness of incorporating Magic squares in arithmetic lessons at the rudimentary level is limited in literature, adding to the novelty of conducting this study. Arithmetic involves numerical computations using operations such as addition, subtraction, multiplication, and division (Wang, 2015). Yet, instructional challenges often lead to learning and problem-solving difficulties. The researchers assert that developing effective pedagogical strategies for arithmetic at the rudimentary level would be essential in addressing those gaps. Thus, this study investigated the appropriateness of Magic Square as a reliable instructional tool for conducting arithmetic lessons.

Kolb's experiential learning theory underpinned the study, emphasizing four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). Children learn best through hands-on activities which allow them to manipulate concrete materials on their own. Participants engaged with Magic Square through direct experience, observed its application in solving arithmetic problems, internalized its use, and formed abstract representations. Finally, they actively experimented with solving both related and unrelated problems using the didactic game. The study aimed to establish a rationale for using Magic Square as a didactic game for teaching arithmetic in Grade 3. The central research question was: *How did the utilization of Magic Square as a didactic game impact participants' performance when solving arithmetic problems?*

2. LITERATURE REVIEW

Primary school learners often face significant challenges in grasping foundational mathematical concepts, necessitating timely and targeted pedagogical interventions (Suriya & Premalatha, 2024). Schoenfeld (2016) advocates mathematics to be taught as an exploratory and evolving discipline, emphasizing pattern recognition, conjecture formulation and reasoning over rote memorization. This perspective underscores the importance of fostering creativity and problem-solving in mathematics education. Within this framework, didactic games offer a promising strategy for cultivating learners' conceptual understanding and mitigating arithmetic-related difficulties (Bragg, 2012). By engaging learners in playful yet purposeful activities, such games align with constructivist principles and support intuitive learning through exploration and discovery.

Building on this theoretical foundation, didactic games can be understood as structured analogues of spontaneous children's activities designed to achieve specific educational objectives. Vankúš (2013) describes didactic games as stimulating tools that enhance engagement, creativity, spontaneity, cooperation, and competitiveness. Their student-centered nature encourages learners to construct knowledge through active participation rather than passive memorization. When applied to arithmetic instruction, didactic games can foster meaningful classroom interactions and support effective facilitation.

Arithmetic problems, as outlined by Demosthenous and Stylianides (2014) involve algebraic symbols, equations, generalizations and numerical relationships. These authors categorize algebra-related tasks into arithmetically situated relations, rule-based relations, and known-unknown relations. Didactic games provide learners with practical opportunities to develop arithmetic skills-particularly addition and subtraction-and to generalize their understanding using mathematical representations.

Bragg (2012) notes that didactic games can be used for drills, warm-up activities, and rewards, but cautions that their application requires careful consideration. Teachers must evaluate the appropriateness of each game for the targeted concept. When thoughtfully implemented, didactic games can enhance learners' creative and critical thinking, thereby improving learners' logical reasoning and problem-solving skills (Zhelal & Kaymak, 2023). Beyond cognitive benefits, didactic games influence learning across multiple dimensions which can be emotional, motivational, social, recreational and therapeutic (Vankúš, 2013). These dimensions suggest that didactic games do not only improve learners' mathematical achievements, but also, those games contribute to learners' holistic development, including sensory, emotional and physical well-being. By engaging learners in concrete experiences and personal reflection, didactic games promote deeper understanding and autonomy in the learning process (Zhelal & Kaymak, 2023).

Given the diversity and complexity of didactic games, selecting an appropriate game requires alignment with learners' developmental levels and instructional goals. Vankúš (2013,) proposes key evaluative questions: (1) How many learners will the game involve, and at what cognitive level? (2) What knowledge, skills, and traits does it develop? (3) What is its impact on instructional effectiveness? (4) How does it influence learners' attitudes? (5) What motivational effects does it produce? Importantly, Vankúš emphasizes that learners should be credited for making effort rather than performance alone. Examples of didactic games suitable for arithmetic instruction include Spot the Mistake, Pyramid Construction, Relay, Mathematical Memory, and Magic Square (Zhelal & Kaymak, 2023). This study focuses on Magic Square, a puzzle-based game designed to teach addition and subtraction. Its structure, a 3×3 grid requiring equal sums across rows, columns, and diagonals, makes it ideal for cultivating deductive reasoning and arithmetic fluency among primary school learners.

Effective implementation of a didactic game should address its thematic area, educational targets, environment, procedure, and assessment strategy (Vankúš, 2021). The thematic area refers to the mathematical content the game is designed to teach. In this study, Magic Square was used to support Grade 3 learners' understanding of arithmetic operations. The educational targets included enabling learners to solve problems involving addition, subtraction, and related expressions through scaffolded and sequential activities.

3. THEORETICAL FRAMEWORK

To evaluate the efficacy of the Magic Square in teaching Grade 3 arithmetic, this study adopted Kolb's experiential learning model as its theoretical framework (Kolb, 1984). Widely applied in educational psychology, Kolb's model outlines a cyclical process comprising four stages: concrete experience, reflective observation, abstract conceptualization and active experimentation. This structure facilitates deep, transferable learning through iterative engagements.

The concrete experience phase encompasses learners interacting directly with the instructional material in this case, Magic Square. This hands-on engagement allows learners to construct new knowledge by drawing on their prior experiences, creativity and feedback. Zhelal and Kaymak (2023) noted that didactic games like Magic Square enable learners to manipulate mathematical structures in playful, low-stakes environments, fostering curiosity and intrinsic motivation. The game's tactile and visual nature supports exploration of number relationships and arithmetic operations, aligning with progressivist and learner-centered pedagogies (Hui & Mahmud, 2023).

The reflective observation stage involves learners analyzing and making sense of their prior experiences. Learners reflect on their interactions with Magic Square, identifying patterns, errors and strategies. This metacognitive process enhances arithmetic fluency and problem-solving, as learners connect procedural actions with conceptual insights (Liu, Wang, & Lee, 2021). Reflection also supports personal meaning-making, a key component of sustained mathematical understanding.

In the abstract conceptualization phase, learners generalize their observations into coherent mental models. They begin to formulate hypotheses about mathematical logic underpinning Magic Square, transitioning from intuitive gameplay to structured reasoning. Vankúš (2021) emphasizes that didactic games serve as a bridge between concrete manipulation and abstract thinking, enabling learners to internalize arithmetic properties and operations.

The final stage, active experimentation, mandates learners to apply their conceptual understanding in new contexts. They solve novel problems, adjust game parameters, or design their own puzzles extending learning beyond the original activity. This phase promotes transfer of knowledge and adaptive problem-solving, especially when learners are encouraged to iterate and explore (Rabbimov, 2020).

Kolb's model provided a robust framework for structuring the instructional use of the Magic Square, guiding learners through a full cycle of experiential learning. By aligning each stage with targeted pedagogical strategies and game-based tasks, the study fostered deeper understanding, sustained engagement, and measurable gains in arithmetic performance. Integrating experiential learning theory with didactic game design offers a compelling approach to addressing persistent challenges in early mathematics education.

4. METHODOLOGY

4.1. Research Design

To ascertain the appropriateness of the didactic game- Magic Square - for primary school arithmetic lessons, the researchers found a case study research design to be appropriate for this study. A case study research design accorded the researchers the leeway to extensively observe and monitor participants in their natural classroom settings. This sufficiently guided the researchers to meaningfully measure the impact the Magic Square had on participants' problem-solving and performance in arithmetic. According to Creswell and

Poth (2018) a case study provides detailed and unabridged account of proceedings at the research field which provides researchers enough evidence to thoroughly answer the research questions being investigated.

4.2. Participants

This study investigated 31 purposively sampled learners from Grade 3 in a primary school in the Northern Cape Province in South Africa. According to Cohen, Manion and Morrison (2007) in purposive sampling, the researcher makes specific choices about which people to include in a study. These learners were from the same school, and they had the same mathematics teacher. They served as participants for this study after they agreed to do so in writing with any form of indemnity involved irrespective of their gender, race, ethnicity and social orientations.

4.3. Ethical Considerations

Informed consent, voluntary participation and confidentiality as ethical procedures were duly adhered to before, during and after conducting this study. On informed consent, the researchers sought for learners' and their parents and/or guardians, as well as the department of education's permission in writing prior to conducting this study. Consent letters were signed by prospective participants together with their parent/guardian and ethical clearance approval letter with reference number: L2.10.2.4.3 was obtained from the Northern Cape Department of Education. On voluntary participation, only self-willing and self-motivated learners were considered as participants in this study. On confidentiality, participants' names and any form of identification of participants were kept anonymous from any third party.

4.4. Explication and Implementation of Magic Square for Solving Arithmetic Problems

The instructional process was partitioned into four stages based on Kolb's experiential learning theory. Each stage is described below with corresponding activities and pedagogical guidelines. This intervention lasted 3 weeks and 12 lessons were conducted - each lesson had a duration of 30 minutes.

Step 1: Classroom setting - Collaborative Learning - Gurteen Knowledge Café Approach

Objective: Enhance engagement and peer learning through structured group interaction.

Pedagogical Intent: This approach supports social constructivism, encouraging learners to co-construct knowledge through dialogue and shared inquiry. It complements the experiential cycle by embedding reflection and experimentation in a collaborative setting.

Guidelines:

- Organize learners into small groups of 3 – 4 participants per group.
- Facilitate brainstorming sessions where learners discuss strategies and solve problems collaboratively.
- Rotate roles (e.g., facilitator, recorder, presenter) to ensure active participation.

Step 2: Concrete Experience (Getting Acquainted with the Magic Square)

Objective: Introduce learners to the structure, rules and procedures of the Magic Square game.

Pedagogical Intent: This stage provides learners with hands-on exposure to the game, allowing them to manipulate numbers and observe patterns. It activates prior knowledge and sets the foundation for deeper learning.

Guidelines:

- Present a 3×3 Magic Square grid with some numbers filled in and others left blank.
- Explain the goal: to complete the grid so that the sums of each row, column, and diagonal are equal.
- Introduce basic arithmetic operations (addition and subtraction) used in the game.
- Demonstrate how the game can be used to solve arithmetic problems.

Suggested Visual: An image of a partially completed Magic Square is illustrated below:

		2
3	5	7
	1	

Step 3: Reflective Observation (Observing and Discussing Strategies)

Objective: Encourage learners to reflect on their experiences and observe how the Magic Square is used to solve arithmetic problems.

Pedagogical Intent: This stage promotes metacognitive awareness and helps learners make sense of their experiences. It supports the development of reasoning and analytical skills.

Guidelines:

- Ask learners to observe completed examples and discuss strategies used to arrive at the solution.
- Facilitate a class discussion or group reflection on patterns, symmetry and arithmetic relationships.

Use guiding questions such as:

- “What do you notice about the sums?”
- “How does changing one number affect the rest of the grid?”

Suggested Visual: A completed Magic Square with equal sums:

4	9	2
3	5	7
8	1	6

Step 4: Abstract Conceptualization (Forming Mental Models)

Objective: Enable learners to internalize and generalize the rules and logic of the Magic Square.

Pedagogical Intent: This stage fosters abstract reasoning and helps learners connect concrete experiences to formal mathematical concepts. It supports the transition from intuitive play to structured problem-solving.

Guidelines:

- Guide learners to **formulate rules** for completing a Magic Square.
- Introduce **arithmetic expressions** and relationships such as central symmetry, multiples, etc.
- Explain the logic behind the central box:
 - (a) The sum of numbers symmetrically opposite to the central box should be equal to **twice** the central number.
 - (b) Each row or column should be equal to **three times** the central number.

Suggested Visual: A diagram showing central symmetry and arithmetic relationships:

A	B	C
D	X	E
F	G	H

Where:

$$\begin{aligned}
 A + H &= 2X \\
 B + G &= 2X \\
 C + F &= 2X \\
 D + E &= 2X \\
 \text{Row sums} &= 3X \\
 \text{Column sums} &= 3X
 \end{aligned}$$

Step 5: Active Experimentation – Solving and Creating Magic Squares

Objective: Allow learners to apply their understanding by solving new problems and creating their own Magic Squares.

Pedagogical Intent: This stage emphasizes application and transfer of learning. Learners test their hypotheses, refine strategies, and engage in creative problem-solving

Guidelines:

- Provide learners with Activity 1 - Section A (numerical tasks) and Section B (non-numerical tasks)
- Ask learners to fill in missing values to complete the Magic Square.
- Encourage learners to create their own puzzles using given constraints.
- Use individual and group work formats to promote collaboration.

Suggested Visuals: Activity 1 (See Appendix 1)

- Section A: Completed Magic Square with numerical arithmetic tasks
- Section B: Completed Magic Square with non-numerical arithmetic task

4.5. Bayesian Negative Binomial Random-Effect Model for Assessing the Impact of a Didactic Game

The marks obtained by students (pre-test and post-test, each out of 50 marks) were recorded on a count scale, thus normality assumption may not hold which makes it inappropriate to use the traditional Analysis of Variance model to test for differences between the marks of the two groups. A more appropriate model for testing for differences in the marks for the two groups is the negative Binomial Random-effect model (Jiang, 2007). This model accounts for differences between participants as a result of variations in learning barriers and abilities and over-dispersion which are common for count data. In estimating

the parameters of the model, one has the option of using traditional methods (frequentist approach) or the Bayesian approach. The frequentist approach however turns to produce inaccurate standard errors for small samples, thus may lead to spurious conclusions and generalizations. The Bayesian approach on the other hand is more useful in stabilizing the estimates, especially in small samples in the case of this study with a sample size of 31 (Follett & Vander Naald, 2020). Thus, it can produce a more accurate result. The Bayesian approach also allows one to incorporate prior information into the model. Although the marks obtained by the participants are within bounds, Hardin and Hilbe (2015) argue that standard negative Binomial models often remain preferable unless counts frequency hit the upper bound, which is not the case in this study. Thus, although our data is bounded, the negative binomial model is still a good and preferable choice. Due to these advantages of the Bayesian framework over the traditional estimation approach, the Bayesian Random-effect negative Binomial model was used in modelling the differences between the marks for the two groups. Here we are interested in testing the following hypothesis:

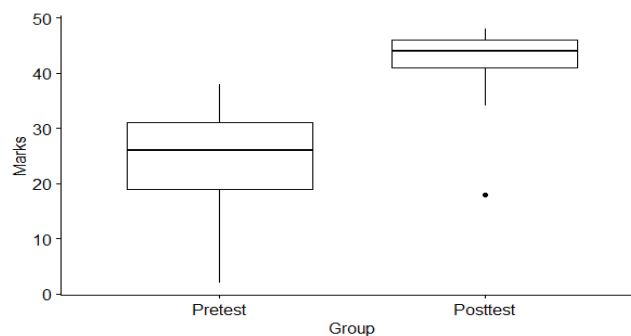
- H_0 : Magic Square is an effective teaching method compared to the traditional approach.
- H_1 : Magic Square is not an effective teaching method compared to the traditional approach.

5. RESULTS AND DISCUSSIONS

5.1. Preliminary Data Analysis

When testing for differences between two populations or samples, a box plot becomes more useful. Although it does not provide a formal test to assess the significance of the differences between the population means or samples, it provides a graphical means to pre-assess if there exist differences in the means of two or more groups. A box plot of the marks for the two tests is presented in Figure 1. It is evident from the plot that the marks of the control group (denoted pre-test) are lower than the marks of the experimental group (denoted post-test). This observation provides a possible indication that the didactic game for conducting arithmetic lessons at the rudimentary level is more effective.

Figure 1.
Box plot of aggregated marks.



5.2. Normality and Over-Dispersion Tests

In this section, the normality and over-dispersion test are presented. The Shapiro wilk's method was used for the normality test. If the data is normally distributed or over-dispersed, the p-value of the test should be less than the conventional 5% level of significance. The results are presented in Table 1.

Table 1.
Over dispersion test.

Test	Test	P-value
Shapiro-Wilk	0.9325	0.00209
Over-dispersion	1.6891	0.04560

It is clear from Table 1 that the data is not normally distributed, but it is over-dispersed. This is because the associated p-values are less than the 5% level of significance. These conclusions suggest the appropriateness of the Bayesian negative Binomial mixed- effect model for modelling the data.

5.3. Model Output and Discussions

Table 2 presents the estimated parameters of the Bayesian model, including the mean estimates, 95% credible intervals (LCI and UCI), and key convergence diagnostics such as Rhat, Bulk_ESS, and Tail_ESS. These diagnostics are essential for assessing the reliability of posterior estimates. For a well-fitted Bayesian model, the Rhat statistic should be close to 1, indicating that the Markov chains have mixed well and converged to the target distribution. Similarly, Bulk_ESS and Tail_ESS values should ideally exceed 1,000, reflecting sufficient effective sample size for both the bulk and tail of the posterior distribution, which ensures stable and accurate estimates. Observations from Table 2 confirm that the model meets these criteria because all Rhat values equal 1, and both Bulk_ESS and Tail_ESS are well above 1,000. This indicates strong convergence and suggests that valid inferences can be drawn from the posterior distributions for both groups.

Table 2.
Estimated parameters.

Parameter	Estimate	LCI-95% CI	UCI -95%	Rhat	Bulk_ES	Tail_ESS
Intercept	3.151	2.9846	3.3081	1	3252	3109
Random effect	0.004	-0.0041	0.0128	1	2984	2969
Treatment	0.5140	0.4249	0.6012	1	6160	2765

To determine if our proposed instructional method significantly improved participants' performance, we assess the estimated parameters and their credible intervals as presented in Table 2. The intercept estimate (3.151) with a narrow credible interval (2.9846–3.3081) reflects stability in the baseline performance. The treatment effect estimate (0.5140) is positive and its credible interval (0.4249–0.6012) excludes zero, providing strong evidence of a treatment effect. This confirms a statistically significant improvement in the post-test scores compared to the pre-test scores. Before attributing this improvement solely to the intervention, it is important to rule out random effects. Since the random effect is not

significant because it has a credible interval that includes zero (-0.0041 to 0.0128). This depicts a random variation in students' performances due to negligible individual differences. Hence, we conclude that the observed improvement in the treatment (post-test marks) is due to the efficacy of the new teaching method rather than uncontrolled variability. Therefore, the evidence strongly ascertains the effectiveness of the intervention approach in enhancing learners' performance in solving basic arithmetic problems.

6. CONCLUSION, RECOMMENDATION AND LIMITATIONS

Conclusions: This study aimed to empirically assess the pedagogical efficacy of the didactic game - Magic Square - as an instructional strategy for foundational arithmetic education. To evaluate the impact of the game-based approach, the study employed a Bayesian negative binomial random-effect model. The analysis revealed that learners exposed to the Magic Square intervention achieved significantly higher post-test scores than those instructed through the traditional approach. These findings are congruent with prior research by Russo, Bragg, and Russo (2021) which underscores the role of mathematical games in cultivating learners' fluency, strategic reasoning, and problem-solving competencies. Similarly, Bragg (2012) emphasizes that non-digital mathematical games, when systematically embedded within structured instructional routines, foster deeper cognitive engagement and promote robust conceptual development. The Magic Square game builds key principles of experiential learning and collaborative inquiry, drawing on the Gurteen Knowledge Café framework to create a dynamic, socially mediated learning environment. Through interactive gameplay, learners engage with arithmetic operations in a concrete and contextually meaningful manner, thereby enhancing mathematical literacy, logical reasoning, and intrinsic motivation (Rahmonkulova, 2024; Booker, 2000).

Recommendations: The empirical validation of the Magic Square as an effective pedagogical tool for teaching arithmetic at the rudimentary level in South Africa has been established in this study. In the studied classroom context, the following recommendations are proposed for similar South African primary school settings. Firstly, schools with comparable learner profiles and curriculum requirements should consider formally integrating the Magic Square game into the foundational phase arithmetic lessons. This integration can be implemented either as a supplementary activity to reinforce core concepts or as part of structured teaching routines where experiential learning is emphasized.

This case study demonstrated that the didactic game aligns well with experiential learning principles and significantly improved learners' fluency, reasoning and problem-solving skills. Therefore, in contexts where rote-based approaches dominate and learner engagement is low, adopting the Magic Square game offers a practical alternative. Its interactive and socially enriched format modelled on the Gurteen Knowledge Café framework proved effective in promoting collaboration and active participation among learners. This suggests that schools aiming to practice differentiated instructions and learner-centered approaches could benefit from incorporating this mode of pedagogy in their lessons.

Secondly, teacher professional development programmes may include training in design, facilitation and assessment of incorporating didactic games in arithmetic lessons such as Magic Square. Educators must be equipped to align game mechanics with specific learning outcomes, manage classroom dynamics effectively, and evaluate learners' progress using both formative and summative tools. This will ensure that the pedagogical benefits of game-based instructions are maximized and sustained across diverse learning contexts.

Thirdly, curriculum developers and policymakers may consider the broader adoption of culturally responsive didactic games in mathematics education. The Magic Square game, adaptable to local contexts and learner needs, aligns with the Department of Basic Education's emphasis on interactive and indigenous pedagogies. Its implementation can contribute meaningfully to national efforts aimed at improving foundational numeracy and reducing learning disparities. In conclusion, the study affirms that the Magic Square game is not merely an engaging instructional tool but a pedagogical interventional approach with demonstrable impact on arithmetic learning. Its adoption within South African schools may represent a strategic step towards more inclusive, effective, and learner-centered mathematics education.

Limitations: The integration of didactic games into arithmetic teaching is not without challenges. Time constraints often limit their use within rigid curricular schedules, and classroom management issues such as noise and off-task behavior can undermine instructional focus. Additionally, disparities in learner participation, misalignment between game mechanics and learning objectives, and difficulties in assessing learning outcomes pose significant barriers. Resource limitations, including access to materials and teacher training, further hinder widespread adoption, particularly in under-resourced educational contexts. To address these limitations, strategic interventions are essential. Time-efficient game formats, structured facilitation protocols, and inclusive design principles can mitigate logistical and equity concerns. Aligning games with specific arithmetic objectives and embedding assessment tools such as observation checklists and learner reflections enhances instructional coherence and evaluative rigor. Moreover, targeted professional development and collaborative resource-sharing among educators can support sustainable implementation. When thoughtfully integrated, didactic games hold substantial promises for enriching arithmetic instruction and advancing learner-centered mathematics education.

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APPENDIX 1

Activity

Complete the following Magic squares by working out the missing values

Section A – Numerical

1.

2	2	6
9	5	1
4	3	8

2.

4	9	2
3	5	7
8	1	6

3.

11	5	10
7	8	9
6	13	5

31
31

4.

13	8	15
14	12	10
9	16	11

5.

4	5	8
9	5	1
2	7	6

6.

70	13	18
15	17	19
16	21	14

Section B – Non-numerical

7.

$7x - 3y$	$2x + 4y$	$3x - y$
$2y$	$4x$	$8x - 2y$
$5x + y$	$6x - 4y$	$x + 3y$

8.

$x - 2$	$x + 5$	x
$x + 3$	$x + 1$	$x - 1$
$x + 2$	$x - 3$	$x + 4$

9.

$x - 2$	$x + 5$	x
$x + 3$	$x + 1$	$x - 1$
$x + 2$	$x - 3$	$x + 4$

10.

$a + 4b$	$7a + 5b$	$8a + 3b$
$6a + 9b$	$3a + 8b$	$2a + b$
$5a + 7b$	$4a + 5b$	$7b$

Chapter # 21

DEVELOPING TRANSVERSAL SKILLS THROUGH CREATIVE TEAM BUILDING IN ENGINEERING EDUCATION

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ABSTRACT

Integrating pedagogical innovations and inclusive approaches in university education supports a shift from passive instruction to active, cooperative learning and the development of transversal skills – particularly collaboration and critical problem-solving – demanded by contemporary engineering and architectural practice. This article presents an experiential team-building intervention implemented in a first-year Building Drawing course at Politecnico di Torino, designed to enhance peer interaction and cooperative decision-making between students from heterogeneous backgrounds. The experiential activity proposes a creative challenge in the field of modular architecture by using the 3D-printed basic element proposed by the architect Walter Gropius. The intervention was evaluated through a questionnaire combined with qualitative classroom observations to capture perceived learning experience and group dynamics. This experience shows how innovative teaching methodologies can strengthen relational and collaborative behaviours and, in parallel, increase student motivation, preparing learners to manage group dynamics and suggesting that inclusive, design-based team building can effectively support the development of transversal skills in AEC education.

Keywords: creative design experience, 3D printing, active learning, student engagement, higher education, transversal skills.

1. INTRODUCTION

In recent years, team-building activities have emerged as effective tools for improving group dynamics and transversal skills in educational contexts, including university programs. In the field of building engineering, where multidisciplinary collaboration is a fundamental requirement for professional practice, the ability to work in teams is as crucial as technical expertise. However, traditional university courses tend to favour an individualistic approach to learning, overlooking the potential of cooperative methodologies in enhancing both student engagement and their preparation for the workforce. Within this context, the present study describes a team-building activity designed for first-year Building Engineering students to develop transversal skills and promote a more cooperative learning process. This gap is particularly relevant in first-year courses, where cohorts are often heterogeneous and students have limited prior experience of academic teamwork. Accordingly, this study is guided by two research questions: (RQ1) To what extent can a creative, design-based team-building exercise embedded in a first-year Building Drawing course facilitate peer interaction and initial interpersonal acquaintance within a heterogeneous cohort? (RQ2) How do students perceive their engagement and motivation during the exercise, and which transversal skills do they report activating while collaborating? Consistently with these questions, the study aims to document and examine – through in-class qualitative

observations and a post-activity questionnaire – how a hands-on collaborative intervention shapes early group dynamics and students’ perceived engagement and collaborative skill use in a first-year Building Engineering setting.

The scientific literature suggests that integrating team-building experiences into higher education can improve academic performance, foster a sense of group belonging, and enhance communication skills (Oakley et al., 2004). Recent studies indicate that approaches such as cooperative learning (Johnson & Johnson, 2017) and problem-based learning (PBL) (Hmelo-Silver, 2004) promote active learning and collaborative problem-solving for complex issues (Gutierrez-Berraondo et al., 2025), thereby strengthening teamwork management skills. Literature syntheses further show that the benefits of PBL tend to emerge more clearly in competence-oriented assessments than in short knowledge-focused tests (Strobel & van Barneveld, 2009). Within this framework, research emphasizes that the effectiveness of such activities depends critically on the instructor’s role, which progressively shifts from a “transmitter” of content to a designer of processes and active learning experiences aimed at maximizing student engagement (Johnson & Johnson, 2017). For cooperative learning to be truly effective, it requires explicit design conditions, rather than assuming that simple “group work” is inherently collaborative. In engineering education, multiple experiences show that practical exercises and collaborative project challenges increase students’ motivation and engagement and may foster deeper learning approaches, although outcomes depend on the quality of scaffolding and on constructive alignment between learning objectives and assessment (Du et al., 2019; Francis et al., 2025). According to evidence-based principles, this relationship is consistent with the idea that motivation directs students’ study behaviours in higher education. Motivation is also strengthened when an activity integrates learning, social, and affective goals, as often occurs in group-based projects (Ambrose et al., 2010; Gauthier, 2013). In parallel, empirical evidence indicates that transversal skills are associated with improved academic outcomes and lower dropout rates, and that project-based practices may contribute to performance also through their role in developing such competences (Guerra-Macías & Tobón, 2025).

Considering these premises, the impact of team-building activities in engineering education can be interpreted across three complementary dimensions. At the formative level, such activities encourage students to connect theoretical concepts with practical applications, fostering critical thinking and creativity in addressing complex problems while supporting flexible knowledge construction and self-directed learning (Hmelo-Silver, 2004). At the social level, they enhance communication skills, promote inclusivity by valuing diverse backgrounds, and strengthen conflict-management abilities, fostering empathy and cooperation – especially when teamwork competences are taught explicitly and supported by fair and transparent assessment practices (Johnson & Johnson, 2017; Francis et al., 2025). It is also important to note that classroom climate and communication patterns can be perceived by students along a continuum from supportive to unsupportive environments, with implications for motivation, learning, and performance: a negative climate may hinder learning, whereas a positive climate can energize it (Ambrose et al., 2010). At the professional level, when these activities are embedded within the curriculum, they simulate conditions close to real-world practice – where engineers collaborate across disciplines – thereby reinforcing soft skills such as leadership, adaptability, and organizational capacity; in this regard, Orih et al. (2024) recommend mixed-methods evaluation and continuous-improvement logics to capture the complexity of socially embedded training interventions. More broadly, as social and emotional processes are particularly salient during the university years, the design of learning environments that can recognize and address

students' socio-emotional challenges is consistent with a student-centred perspective oriented towards "teaching students, not just content" (Ambrose et al., 2010).

The remainder of the paper is organized as follows: Section 2 delineates the educational context; Section 3 presents the methodological framework, detailing the design, implementation, and evaluation procedures; Section 4 reports the results; Section 5 outlines directions for future research; and the concluding section synthesizes the main findings and implications.

2. EDUCATIONAL CONTEXT

The team-building approach was experienced in the Building Drawing course at Politecnico di Torino, which lays the methodological foundations of Drawing as a communication language for engineers. As the first core course of the Building Engineering Bachelor's program, it brings together students who had previously been distributed according to different criteria, creating a cohort characterized by diverse educational and cognitive backgrounds. In this context, the experiential activity was designed to establish a collaborative learning environment and foster mutual acquaintance among students. These aspects are considered essential both for the practical group-based tasks that are central to the course and for building interpersonal relationships that are instrumental for subsequent teaching experiences. Sixty-five students from a variety of educational pathways – including high schools, technical institutes, and surveyor schools – participated in the activity.

This experience is integrated within a broader pedagogical teaching strategy adopted in the course that combines multiple teaching approaches to support the formation of competent and reflective engineers. Innovative learning experiences such as this are part of an articulated action plan (Ugliotti, Aschieri, & Osello, 2023; Ugliotti, & Zucco, 2023) with four principal objectives: (i) Providing diversified learning tools and strategies to facilitate the restructuring and elaboration of knowledge, enabling students to form cognitive connections and stimulate critical thinking. (ii) Encouraging students to experiment with mental strategies for developing personal interpretations of theoretical concepts presented in class, thereby constructing individualized understandings or mental models. (iii) Promoting experiential learning through “learning by doing”, allowing students to test, manipulate, and apply concepts in tangible, often collaborative contexts. (iv) Enhancing students' self-efficacy and self-assessment skills, giving them opportunities to reflect on personal performance and learning outcomes.

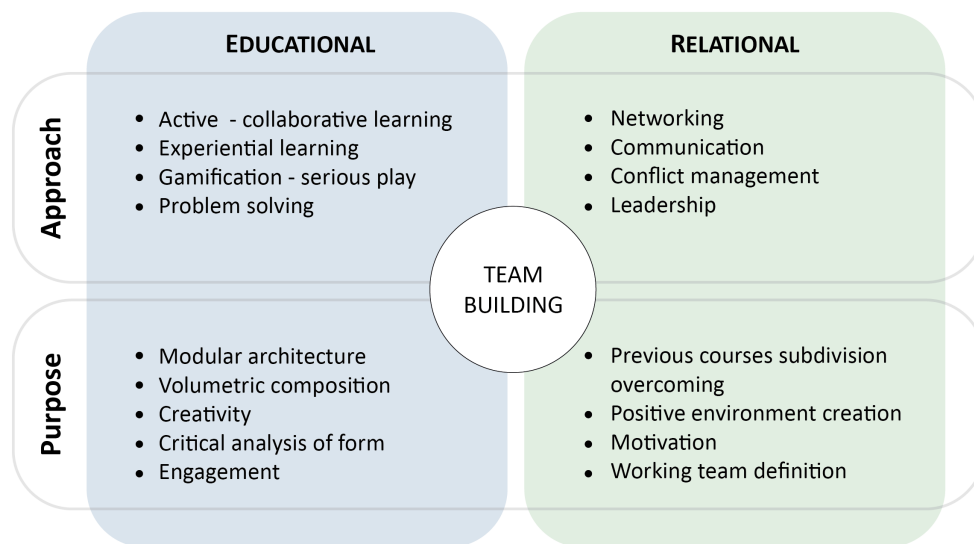
By situating the team-building activity within this framework, the course not only emphasizes technical competencies but also creates a methodological bridge between theoretical instruction, hands-on practice, and relational development. This approach reflects a broader trend in engineering education, where integrating active, collaborative, and reflective learning strategies is recognized as essential for fostering both disciplinary knowledge and transversal skills.

3. METHODS

The concept of modular architecture had been previously introduced to the students alongside the case study selected for the course: the Masters Houses of the Bauhaus in Dessau, designed by the architect Walter Gropius and built in 1925. This case represents not only an architectural milestone but also a pedagogical example of how form, function, and rationality can converge in design through modular systems.

Building on this premise, the participatory activity proposes a creative challenge in the field of modular architecture, which entails the definition of volumetric forms using the basic modules proposed by Gropius (Seelow, 2018). The use of modularity as a conceptual and operative framework enabled the design of a dynamic team-building activity that was both directly connected to the disciplinary content of the course and pedagogically aligned with the broader objectives of engineering education. The activity was conceived with the dual purpose of consolidating disciplinary learning and enhancing relational skills, as summarized in Figure 1.

Figure 1.
Methodological approach.



From a pedagogical perspective, the adoption of active approaches within the course (Ugliotti, Aschieri, & Osello, 2023) was aimed at directly involving students in the learning process, stimulating their participation, reflection, and collaboration. Techniques such as collaborative and experiential learning, gamification and serious play, and problem-solving were integrated into the experience to create a fertile synergy between theory and practice. In this framework, modular architecture served as a “didactic catalyst,” transforming abstract concepts into manipulable forms that could be tested, assembled, and reinterpreted. This strategy facilitated the simultaneous development of disciplinary skills – such as graphic representation, spatial reasoning, and compositional analysis – and transversal competencies, including critical thinking, adaptability, and cooperative problem-solving.

Engaging in active learning experiences (Prince, 2004) compels students to confront design challenges in real time, sharpening their capacity for creativity while encouraging them to think through iteration, experimentation, and negotiation. In this case, the activity stimulated critical analysis of form and structure, creativity in volumetric composition, and a deeper reflection on expressive and constructive methodologies associated with modular systems. By situating the exercise within the historical and cultural framework of Bauhaus principles, students were also encouraged to link past architectural theories with

contemporary design practice, thus broadening the cultural and intellectual dimension of the learning process.

The relational outcomes of the activity proved equally significant. Working in groups to reconfigure modular elements stimulated communication and networking skills, revealed natural tendencies toward leadership, and required conflict management strategies. Such dynamics highlight how technical knowledge and social competencies are interdependent in engineering education. The creation of a positive environment, reinforced by shared motivation and collective responsibility, contributed to the formation of cohesive and functional workgroups. In this sense, the team-building experience assumed a central role in the educational journey, acting as a transversal component capable of integrating pedagogical goals with relational needs.

The activity involved three main phases: an initial design phase, where the teaching team conceived and planned the activity; a practical execution phase, involving the assembly and manipulation of modular elements; and a final evaluation phase, in which results were critically discussed and assessed (Figure 2).

Figure 2.
Activity phases.



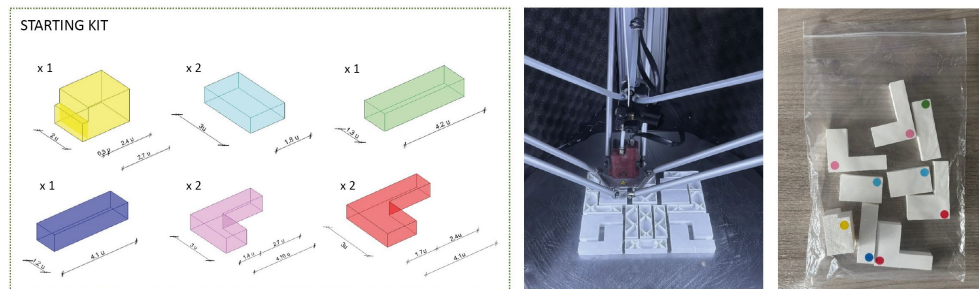
3.1. Design of the Activity

The preparatory phase of the activity entailed the digitalization of Walter Gropius's 1922 *Baukasten im Großen* modular forms, which were modelled in 3D using Autodesk Revit software. Once modelled, the digital objects were exported into the slicing software Ultimaker Cura, where they were optimized for 3D printing. At this stage, particular attention was devoted to scaling: the modules had to be sufficiently large to ensure ease of handling and visibility during group work, while at the same time avoiding excessive bulk that could hinder manipulation or transport. This process allowed the definition of a balance between functionality and practicality, ensuring that the printed modules would serve as effective pedagogical tools and could be easily reused in different settings. The final kit, consisting of nine modules, was printed in 40 identical sets, guaranteeing that each group could work under the same conditions. In parallel with the technical preparation, an external pilot simulation was conducted with volunteer students not enrolled in the Building Drawing course. This step was planned a priori as a dress rehearsal to test the feasibility and workability of the activity protocol and data-collection instruments, and to refine key implementation variables before running the intervention with the target cohort (Lenzner et al., 2024). This choice ensured that the participants would approach the task without prior conditioning and allowed the teaching team to observe spontaneous action. The simulation proved crucial in calibrating

the timing of each phase, in defining the number of participants per group, and in adjusting the sequence of regroupings to maintain the possibility of dynamic collaboration. Moreover, the test offered the opportunity to design the data collection form more effectively: the requests were refined based on the feedback collected during the simulation. Interestingly, the pilot participants also contributed with critical and proactive suggestions that enriched the structure of the activity. For example, they proposed the idea of naming each composition, introducing an additional expressive dimension that would later become an integral part of the documentation phase. This element revealed the potential of the activity not only to stimulate creativity through form-making, but also to stimulate dialogue and idea-sharing among students. The process of naming the compositions prompted them to collectively interpret the generated forms, establishing connections with structural and architectural concepts.

The design and preparation of the activity required considerable time and resources from the teaching team. In particular, the processes of 3D modelling, printing, prototyping, and the pilot simulation demanded meticulous planning and continuous coordination to ensure that both the physical modules and the overall structure of the activity would meet the pedagogical objectives.

*Figure 3.
Design phase.*

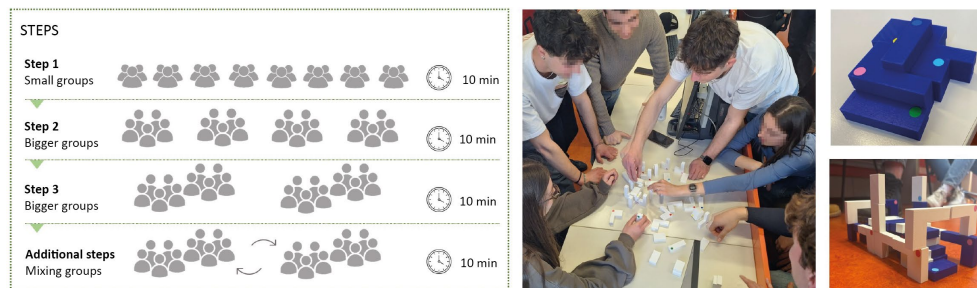


3.2. Execution of the Activity

The team-building activity was conducted during regular class hours, within a lecture hall equipped with aligned rows of desks placed side by side. Students had been informed in advance that they would be taking part in a team-building session, yet the specific nature of the task remained undisclosed to preserve the element of surprise and spontaneity. The instructions of the activity were presented through slides projected in the classroom and remained visible throughout the exercise, ensuring that students could easily refer to the information while working. The activity unfolded in a series of progressive stages. Initially, groups of two or three students formed according to physical proximity. Each small group received a starter kit of modular elements contained in a transparent plastic envelope and was asked to assemble free compositions using the modules provided. No constraint was imposed on the use of all available elements nor on the number of compositions, leaving room for diverse creative strategies. As the process advanced, groups were gradually merged, doubling the number of participants and pieces available, thereby stimulating new interactions and increasing the complexity of the design tasks. In later phases, reorganizations followed a different logic: groups were reshuffled independently of seating arrangement and without increasing the number of individuals, with the main objective of facilitating interactions

among as many students as possible. Each construction phase lasted approximately ten minutes. At the end of every step, students documented their work by completing a form recording the name of participants, the number and type of modules employed, the chosen name for the composition, and a photographic record of the model. This systematic documentation provided the basis for subsequent analysis of both relational and formal outputs.

Figure 4.
Execution phase.



3.3. Evaluation of the Activity

During the activity, the teacher and collaborators paid special attention to qualitative observations of the dynamics among the students and the effectiveness of the planned task. Moreover, a structured questionnaire was administered to all participating students at the end of the session. The instrument was designed to collect both quantitative and qualitative feedback, with the purpose of assessing the pedagogical effectiveness and relational impact of the activity. The questionnaire was articulated into five sections. The first explored students' perceptions of the objectives and benefits of the activity, assessing to what extent the activity was able to promote teamwork and facilitate interpersonal acquaintance. A second section was dedicated to engagement and participation, measuring personal involvement and motivation, the skills applied, and the quality of each student's contribution within the group. The third part addressed organization and dynamics, focusing on the clarity of the instructions received, the adequacy of the time allocated, and the effectiveness of the group structure in supporting collaboration. Attention was also given to the interest in the proposed theme, in order to understand whether the conceptual reference to modular architecture stimulated curiosity and sustained attention throughout the activity. Finally, a section on future experiences investigated the students' willingness to take part in similar initiatives again, while also collecting suggestions for improvement concerning the format, duration, and integration of such activities into the course. The questionnaire combined closed-ended questions, using rating scales to allow measurable comparisons, with open-ended prompts that enabled students to provide personal reflections and suggestions. The systematically collected data served as the basis for subsequent analyses of relational dynamics and educational implications.

4. RESULTS

The team-building experience revealed several relational dynamics with important pedagogical and social implications. During the activity, the teacher and her collaborators observed that, each time a new group was formed, participants overcame interpersonal barriers through a spontaneous self-introduction phase (Figure 5.a), fostering a climate of openness and reciprocity. From the very first phase, devoted to small group formation, different approaches to problem solving emerged. Most participants adopted active collaboration (Figure 5.b), while in some cases a more individualistic approach was observed (Figure 5.c), in which each member focused independently on his or her own construction, emphasizing personal operational styles. In later stages, and thus with larger groups, the relational approach took on even more diverse forms. Some groups adopted parallel methods that facilitated a synergistic and equitable distribution of tasks (Figure 5.d), while others experimented with sequential strategies (Figure 5.e) in which one segment of the group devoted itself to constructing the form and another to prototyping the composition. The latter dynamic is symptomatic of a spontaneous predisposition to effective coordination. Just in a few isolated cases, a lack of engagement by some participants was observed, highlighting the need to implement motivational and inclusive strategies, as well as to create an environment more conducive to collaborative activities, in order to encourage active participation and the development of optimal group dynamics.

Figure 5.
Main relational dynamics observed.



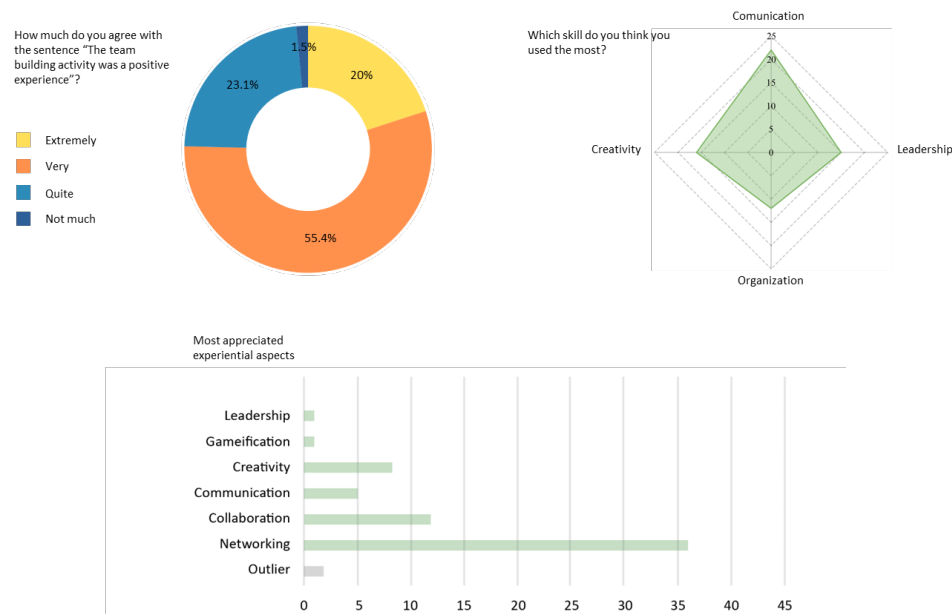
The post-activity questionnaire highlighted additional experiential and relational dynamics. Responses regarding perceived objectives and benefits indicate an overall very favourable evaluation: about three quarters rated the experience as “very” or “extremely” positive, and almost all respondents provided a positive assessment when including the “fairly” option.

Consistently, the great majority reported feeling engaged and stated that the activity helped them meet new classmates, although the presence of a small number of negative responses suggests that the effect was not fully uniform and calls for attention to the inclusion of more peripheral participants. In terms of engagement and participation, the opportunity to express one’s ideas was rated highly (approximately 97% positive responses), yet with a non-negligible concentration on “fairly,” pointing to room for improvement in balanced turn-taking and more symmetric participation within groups. In parallel, the most frequently mobilized competences were communication (about 34%) and creativity (about 25%), followed by leadership (about 23%) and organizational skills (about 19%), outlining a profile consistent with a task based on negotiation, coordination, and shared decision-making. With respect to organization and dynamics, the instructional design appears robust: the instructions were perceived as clear almost unanimously, while the overall duration was considered

adequate by most respondents (about 92%) but insufficient by a minority (about 8%), indicating that timing is a sensitive variable to refine, particularly during regrouping and realignment phases. Regarding interest in the proposed theme, the activity triggered a design-oriented reading aligned with the course: about 94% reported interpreting the configurations as “buildings” while assembling them; however, the increase in curiosity toward modular architecture was less uniform (about 83% positive, about 17% reporting little or no increase), suggesting that for part of the cohort the link between hands-on composition and the conceptual framework could benefit from more explicit debriefing and shared interpretive prompts. Finally, in relation to future experiences and open-ended feedback, almost all respondents considered it effective to place team-building at the beginning of a course (about 99%), and a large majority would like to repeat similar activities in other courses (about 89%), indicating high acceptability and perceived transferability; open-ended responses further confirm that networking was the most appreciated aspect (followed by collaboration and creativity) and that suggested improvements mainly concerned time, group organization, and space/layout, highlighting that key levers lie in implementation conditions rather than in the theme itself.

In addition, communication and creativity emerged as the most frequently utilized soft skills, proving to be essential for effective teamwork and problem-solving (Figure 6).

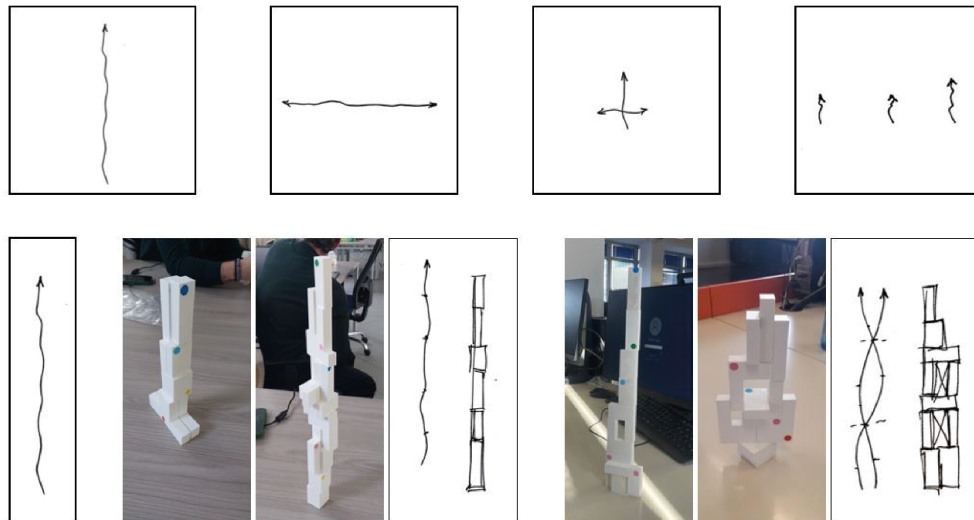
Figure 6.
Form results evaluation.



Overall, these operational strategies contributed significantly to the development of key relational competencies and soft skills, including communication, networking, conflict management, and leadership. Such skills are indispensable for fostering cohesive and efficient teams in educational contexts, while simultaneously providing valuable preparation for the future Building Engineer.

Beyond the relational and collaborative dynamics observed, an additional outcome of the activity concerned the creative composition of forms using the modular kits. For first-year Building Engineering students, this represented an initial, hands-on encounter with the notion of design, enabling them to explore spatial organization, structural thinking, and compositional strategies in a tangible and collaborative setting. The artefacts produced by each group were systematically documented through the data-collection forms and photographic records, allowing an initial identification of recurring compositional logics and emerging design tendencies (Figure 7). Importantly, this documentation did not serve only an analytical purpose: it was subsequently shared and discussed with the students, becoming the starting point for a guided debriefing and a structured pedagogical pathway. Through the collective review of the results and the observed strategies, the activity was used to explicitly introduce and consolidate core disciplinary notions – such as modularity, spatial reasoning, and the relationship between structure and form – by connecting students' self-produced artefacts to the theoretical concepts addressed in the course. In this way, form-making functioned not only as practice, but as a scaffolding device that helped bridge experiential exploration and conceptual formalization, laying the groundwork for more advanced architectural and engineering reasoning in subsequent courses.

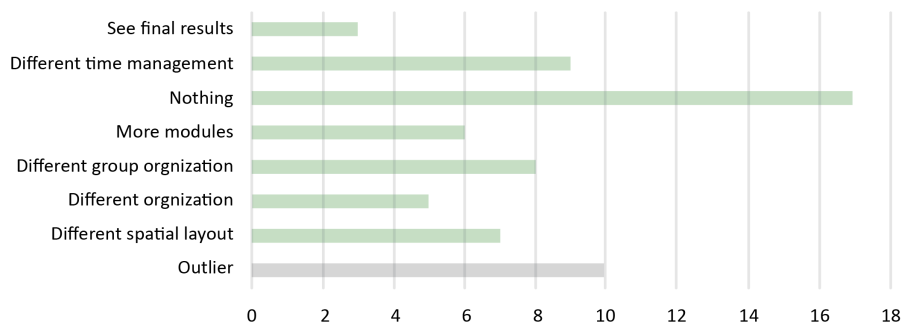
Figure 7.
Design tendencies observed.



5. FUTURE RESEARCH DIRECTIONS

The present pilot experience demonstrates the potential of team-building activities based on modular composition to foster both relational and creative skills in first-year Building Engineering students. Given the positive outcomes observed in terms of engagement, collaboration, and interpersonal interaction, this approach could be replicated and adapted in other educational contexts. During the evaluation phase, additional proposals and suggestions for future implementations of the activity were collected, as summarized in Figure 8.

Figure 8.
Suggestions for future team-building activities from the questionnaire.



Future implementations could systematically test variations in the number of participants, the duration of each phase, and the size of working groups in order to identify an optimal balance between intensity of interaction and manageability of coordination. In particular, these parameters should be treated as interdependent variables: larger groups may increase diversity of ideas but also raise negotiation costs, while shorter timings can sustain focus but may limit deeper cooperation. Additionally, alternative arrangements for group formation and phase sequencing could be explored together with classroom layouts that move beyond the traditional “frontal” setup – typically characterized by aligned desk rows facing the lecturer – and instead support collaborative exchange. Configurations such as well-spaced round or square tables, flexible islands of desks, or modular stations that allow groups to face each other and circulate between work areas may reduce physical barriers, facilitate eye contact and dialogue, and ultimately strengthen collaboration and peer interaction. Moreover, while the current activity focused on modular architecture as a didactic medium, similar strategies could be designed around other subject-specific themes relevant to the course of study, offering students a “soft” introduction to disciplinary concepts through hands-on, collaborative, and creative exercises. For instance, a structural form-finding tabletop challenge could engage student teams in building small-scale structures using simple elements (e.g., sticks, rubber bands, clips, and weights) with the goal of maximizing height, span, or load-bearing capacity. Beyond introducing core principles such as intuitive statics, triangulation, constraints, and structural behaviour, this format would also activate key transversal competencies – such as distributed leadership, collaborative problem-solving, and conflict management – as groups negotiate design choices under time and resource limitations. Further research will investigate how such interventions can be refined and tailored to maximize educational, relational, and cognitive outcomes.

6. CONCLUSION

This study documented and analysed, from a pedagogical perspective, a creative team-building activity designed to support the development of transversal skills and to foster interaction among students with heterogeneous backgrounds within a first-year Building Drawing course. The creative challenge, situated in the context of modular architecture, involved the use of building modules inspired by Gropius’ designs, modelled and 3D printed, offering participants the opportunity to reinterpret architectural space in a personal way. In

addition, it enabled students to explore the compositional, graphic, and spatial principles that constitute its theoretical and practical underpinnings.

In response to (RQ1), the collected evidence suggests that the exercise effectively facilitated peer interaction and the initiation of mutual acquaintance within the cohort. Classroom observations showed that, at each regrouping stage, students tended to overcome initial barriers through spontaneous self-introductions and rapid negotiations, progressively activating coordination dynamics (including parallel and sequential working arrangements). These qualitative insights are consistent with questionnaire data, which indicate a highly perceived usefulness of the experience both for meeting new classmates and for positioning team-building activities effectively at the beginning of the course. Although the intervention is student-centred, the literature also invites consideration of the instructor's role, which emerges as decisive: no longer a mere transmitter of content, but a designer of structured learning experiences aimed at sustaining participation and maximizing active student engagement. In this sense, the activity can be interpreted as a cooperative learning device: regrouping and the need to reach operational agreements required continuous use of communication skills and the progressive construction of peer collaboration practices.

In response to (RQ2), questionnaire results indicate high levels of engagement and a widespread perception of participation, together with the activation of specific transversal skills during collaboration. Students mainly reported mobilizing communication and creativity, followed by leadership and organizational skills, outlining a profile consistent with a task grounded in comparison, coordination, and shared decision-making. While not a PBL pathway in the strict sense, the exercise incorporates a problem-based logic: heterogeneous groups address an open-ended task and negotiate solutions through cycles of trial, discussion, and reorganization, activating collaborative problem solving and transversal skills within an active learning context. At the same time, response distributions indicate that the quality of the experience also depends on implementation conditions such as timing, regrouping phases, and the balancing of participation.

Beyond these relational and organizational aspects, the experience also highlighted the potential of experiential activities to act as “gateways” to theoretical knowledge. By engaging directly with modular elements, students were able to internalize architectural principles – such as modularity, repetition, and scalability – not only as abstract notions but as concrete design strategies tested in practice. This embodied approach resonates with constructivist theories of learning, according to which knowledge is consolidated through the continuous interplay between action, reflection, and conceptualization. In this way, the activity bridged the gap between theory and practice, enabling heterogeneous groups of students to access disciplinary content through multiple cognitive channels – visual, spatial, and kinaesthetic – thereby reinforcing inclusivity.

Overall, this pedagogical model, potentially replicable across educational settings, contributes to the discourse on educational innovation by showing how advanced technological tools and interdisciplinary approaches can foster academic and relational competences on solid, critical, and collaborative foundations, break the monotony of passive listening, and promote broad, conscious participation. However, the outcomes should be interpreted as observational and perceptual evidence (in-class observations and post-activity self-reports), rather than as causal or pre-post measures of competence improvement. The study further suggests that active and experiential learning can enrich the assimilation of theoretical knowledge, preparing students to face the dual challenge of mastering disciplinary content while cultivating the social and collaborative skills essential for contemporary professional practice.

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KEY TERMS & DEFINITIONS

Transversal skills: capabilities not tied to a single discipline and applicable across multiple contexts, encompassing effective communication, collaboration, critical thinking, creativity, leadership, and organizational abilities. These skills underpin interpersonal interaction, conflict management, and shared decision-making processes.

Active learning: a pedagogical approach that requires learners to engage actively through participation, reflection, and interaction. It promotes deeper cognitive processing by integrating practical tasks, cooperative activities, and problem-oriented strategies.

Team building: a structured set of activities designed to strengthen communication, trust, cooperation, and cohesion within a group. It supports the development of effective interpersonal relationships and facilitates productive collaborative dynamics.

Modular architecture: a design framework based on repeatable and combinable units that enable the generation of flexible spatial configurations. It provides a foundation for examining compositional principles, constructive logic, and standardization processes.

Collaborative problem-solving: a collective problem-resolution process in which individuals contribute ideas, assess alternatives jointly, and coordinate their actions to achieve a shared objective.

3D printing: an additive manufacturing technology that produces three-dimensional objects through the progressive layering of material derived from a digital model. It allows rapid prototyping, geometric experimentation, and the fabrication of complex forms.

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Chapter # 22

TEACHING LAW IN THE AGE OF ARTIFICIAL INTELLIGENCE: TIME FOR CURRICULUM REFORM?

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ABSTRACT

A revolution has been introduced by the introduction of generative artificial intelligence (AI). Generative AI systems can now perform activities relating to problem-solving and decision-making. The introduction of AI questions traditional approaches to teaching and learning but brings with it a plethora of ethical issues such as academic integrity. Curriculum policy documents on legal education in South Africa outline essential skills for law graduates such as reading, writing and research skills. None of these documents speak to the ethical use of AI tools. The central question of this study is: what aspects of legal curricula in South Africa should be addressed to adequately prepare law graduates for the legal profession in the age of AI? The first part consists of a consideration of the relevant skills that are needed for law graduates in the age of AI. The second part evaluates the various quality standards documents on legal education in South Africa against the findings in the first part. The final section will propose recommendations for curriculum reform. This paper concludes that legal curricula must incorporate skills training aimed at the use of AI tools.

Keywords: legal education, artificial intelligence, curriculum, ethics.

1. INTRODUCTION

The world has been revolutionised by the introduction of generative artificial intelligence (GenAI) to the public towards the end of 2022. What makes GenAI revolutionary is that it can perform tasks that were previously thought to only be performed by human beings, such as text and image generation, knowledge representation and text analysis (Nowrozy and Jam, 2024). At universities, GenAI tools such as ChatGPT have been used for tasks such as language and grammar correction, information searches and text generation. The use of GenAI tools brings with it a host of ethical dilemmas including academic integrity, bias and privacy (Floridi, 2024; Mahmud, 2024). Academic integrity could potentially be compromised as students might submit GenAI answers as if they are not their own. Bias might be present as the data that GenAI relies upon might be biased towards a group of people. Privacy issues might be implicated by GenAI as personal information that is shared with a GenAI tool is not necessarily protected. The rapid introduction of GenAI questions the responsiveness of university curricula.

This paper focuses on legal education in South Africa, specifically teaching practices as it relates to GenAI. GenAI tools are increasingly being used by legal practitioners to draft documents and find relevant information (Magesh *et al.*, 2024). The central question of this study is: which aspects of legal curricula should be adapted to adequately prepare law students for the legal profession in the age of GenAI?

The first part of the paper considers the context of legal education in South Africa and the requisite skills law graduates should have. Drawing from various studies, the second part of the paper considers the potential to use GenAI to develop some of the essential skills mentioned in policy documents on legal education. The last part recommends changes to legal curricula in South Africa.

2. LEGAL EDUCATION IN SOUTH AFRICA

The first democratic legal education in South Africa started in 1998 with the adoption of *The Qualification of Legal Practitioners Amendment Act* of 1997. The aim of democratic legal education was to provide quality legal education that was equitable and accessible (Gardbaum, 2015). Already, early on in the programme there were complaints from academics and legal practitioners that students were lacking literacy skills such as writing and reading (Gardbaum, 2015). To address the concerns of various stakeholders a legal education summit was held in 2013 where a task team was constituted that would set up a standards document relating to skills and standard setting (Sedutla, 2013). The task team, after comment by relevant stakeholders and approval by the Council for Higher Education (CHE), set up a document that contained the required knowledge, skills and applied competencies that all law graduates should achieve at the end of their academic study for their law degree. Students should have a basic knowledge of law subjects (Council on Higher Education, 2015). The skills and competencies, also known as graduate attributes, that law students should demonstrate include the following: critical thinking skills, research skills, ethics and integrity, communication skills and literacy, numeracy, information technology, problem solving, self-management and collaboration, transfer of acquired knowledge, agency accountability and service to the community (Council on Higher Education, 2015).

All Bachelor of Law (LLB) programs in South Africa were reviewed during 2015-2016 using the LLB standards as a guiding document. The report by the review panel found that knowledge of law was not found to be problematic (Council on Higher Education, 2018). While most universities had various interventions aimed at research and writing, it did not always translate into success where students were not assessed on reading and writing in individual modules (Council on Higher Education, 2018). Half of the law faculties were found to be lacking in the development of critical thinking (Council on Higher Education, 2018). Instances where critical thinking was lacking the panel noted the presence of rote learning and a lack of robust class discussions (Council on Higher Education, 2018). The report noted that there were no modules dedicated to computer literacy and based on the self-evaluative reports by the different faculties it was taken as conclusive that training was sufficient. Amongst the recommendations made by the panel was that more assessments should be set that assess reading, writing and research skills (Council on Higher Education, 2018).

The abovementioned policy (Council on Higher Education, 2015) and report (Council on Higher Education, 2018) indicate the essential skills for law students. The documents are close to silent on the ethical use of AI tools or other technological systems. This is understandable, as these tools have only been used in the last three years. However, given the rapid rate of change and development, law schools should start thinking about how AI tools can enhance graduate attributes. Law schools should also continuously consider which skills remain relevant for the working world students will enter. The next section considers the potential of AI tools to enhance some of the essential skills of law students namely writing, critical thinking, research skills and problem solving.

3. POTENTIAL SKILLS ENHANCEMENT WITH GENAI

3.1. Writing

As alluded to above, writing is an indispensable skill for a lawyer. Good writing is also part and parcel of good communication. For many years academics and legal practitioners in South Africa have lamented that the writing skills of law students are not up to standard (Crocker, 2018; Greenbaum & Bangeni, 2019). Some authors have argued that GenAI tools can be used for more routine tasks in relation to writing including drafting outlines, bouncing ideas, technical corrections, stylistic and grammar corrections (Costa et al., 2024; Regalia, 2024; Alkamel and Alwagieh, 2024). In the South African context, most law students are not native English speakers. Tools such as Grammarly and Quillbot can be useful in assisting students to convey their ideas. If GenAI can be used for the routine tasks, such as language correction, more time can be freed up in lecture halls to focus on higher order skills such as critical thinking. One of the most common uses of using AI tools is for language editing. The idea is that students would write a text and then use these programmes to correct grammatical and language errors. These tools are generally well accepted, aside from the debate on whether students need to learn language skills in the traditional manner. Arguments in favour of GenAI correction tools suggest that it is no different than using a human language editor or even the spellchecker on MS Word (Lewis, 2024). Furthermore, several studies suggest that language editing GenAI tools are not just useful for editing the written product but helping students learn from their errors (Amyatun and Kholis, 2023; Weber et al., 2025).

Are there some possible dangers if we leave all our writing up to GenAI? There could potentially be. Writing is a process of editing and correcting, a first draft is rarely what any student submits for an assessment. Tu et al., (2024) adds that writing is a creative process and students might lose out on the development of a (better) legal argument in the drafting process when using GenAI. Writing should be seen as a form of thinking (Tu et al., 2024). Williams (2024) suggests placing greater emphasis on oral examinations, to counteract potential academic misconduct. For example, where students are required to submit a written assignment, it should be accompanied by an oral component to test their knowledge. Group, or collaborative assignments, have also been proposed as a safeguard against overreliance on AI. Williams (2024) is of the opinion that students might have a stronger sense of accountability when working with other students in a group.

It has been suggested that corpus linguistics and GenAI can be used to improve writing of students. Discipline-specific corpora has long been used as a method to improve the vocabulary of students. Cheung and Crosthwaite (2025) suggest using corpora in the form of chatbots to enhance disciplinary writing. This approach, rather than just a GenAI tool such as ChatGPT, increases creditability and accountability of the tool as the sources of information are more controlled (Cheung and Crosthwaite, 2025).

While GenAI can be used to correct grammar and stylistic errors in the writing process there might be potential harm if AI is expected to do the bulk of legal argumentation. GenAI should not be used as a substitute for the writing process but as tool to enhance the final product. Tu et al. (2024) maintain that overreliance on GenAI might stifle the lawyer's creative process and thereby hinder legal developments.

3.2. Critical Thinking

As mentioned above, law graduates need to demonstrate the ability to engage critically and analytically with law. The LLB Standards (Council on Higher Education, 2015) includes under critical thinking skills the ability to 'analyse, synthesise, judge critically and evaluate

problems and situations' (LLB Standards - Council on Higher Education, 2015). One of the concerns about the use of GenAI tools by students is that over-reliance on it will lead to a decline in critical thinking and analytical skills (Costa et al., 2024; Prakasha and Nair, 2024). Critical thinking is related to the essential decision-making process of legal practitioners. Critical thinking can be contrasted with naïve thinking. Moppett (2025) notes that legal practitioners exercise these critical thinking skills when they decide on a litigation strategy, exercise judgment in legal matters or develop client relationships. Lawyers will need to use their critical thinking skills to assess answers produced by GenAI. It is this skill that law lecturers need to home in on. Critical thinking should be thought of as a process rather than a final event. James and Burton (2017) describe critical thinking as a process, involving interpretation, analysis, evaluation and synthesis. Interpretation involves understanding the meaning of a statement before the evaluation has started. The second phase of critical thinking involves analysis. James and Burton (2017) describe analysis as a deepened understanding. At this stage, the student needs to identify the underlying assumptions and principles relating to the statement identified in the first phase (James and Burton, 2017). The third phase, evaluation, consists of questioning the statement in terms of accuracy, legality, reasonableness, persuasiveness, theoretical soundness or any other relevant criteria (James and Burton, 2017). The final phase, synthesis, consists of a consolidation of the first three phases that culminates in the student's own conclusion (James and Burton, 2017).

GenAI can be used to stimulate critical thinking in its various stages set out by James and Burton (2017) above. During such an exercise, students will need to go through the steps of critical thinking. Bliss (2024) suggests asking students to prompt an answer from GenAI whereafter they are allowed to evaluate the answer given. Although GenAI is used, such an assignment still develops critical thinking and analytical thinking skills. Furthermore, such an exercise acquaints students with the use of AI. Dietis (2024) suggests prompting AI to produce arguments for and against a topic and asking students to give a (substantiated) answer as to which they prefer. Youn, Park and Murphy (2024) suggest giving an article to students to read and summarise and then prompting a summary from GenAI on the article whereafter students critically engage with that summary. In this way, students must evaluate the answer given by AI. Students might also be encouraged to use AI in a Socratic method (Orynnbassarova and Porta, 2024). In other words, the better the quality of their questions, the better answers they will receive. Bliss (2024) suggests that law students revise and refine a draft answer produced by AI, and using AI has a debate partner rather than naively accepting the first answer given. There are some aspects to be mindful of when using GenAI tools to enhance critical thinking. Darwin et al., (2024) note that although GenAI has the potential to enhance critical thinking, it could create 'echo chambers' as it is limited in the number of perspectives that it can produce. Liu et al. (2025) describe 'echo chambers' as spaces where groups emphasise one particular viewpoint and discredit any outside viewpoint. Echo chambers are detrimental to the development of critical thinking as it might be difficult to think critically about perspectives without alternative perspectives and viewpoints. Other limitations identified by Darwin et al. (2024, p. 15) in their study include oversimplification of concepts by AI and lack of personalization in AI algorithms. Tertiary education usually involves studying complex concepts. The study of law involves studying concepts, but the application of rules and the changing scenarios are not always as straightforward as they may appear. Furthermore, the lack of personalisation in algorithms restricts critical analysis by not tailoring searches to individual criteria (Darwin et al., 2024)

3.3. Research Skills

There are potential benefits of using Gen AI for the development of research skills (Balan, 2024). Gen AI has been beneficial in the initial brainstorming phase of research (Songkram et al., 2024). An additional benefit of GenAI is that it can speed up productivity during the research process. Traditionally, a person may have to use search engines to look up literature on a topic. With the use of GenAI, a person may, for example, prompt the search of the most notable works on a topic. On some search engines, Gen AI is being used to summarise key points or findings in publications. These tools can greatly speed up the initial process of finding and identifying literature (Faber, 2024). Gen AI might also be able to assist with creating an outline for a research paper. AI-powered search engines are already being used in legal practice., including Lexis+ AI and Westlaw AI – Assisted Research which are large language models used as legal research tools to find court cases, legislation and other legal documents (Magesh et al., 2025). Clearing up time with more routine tasks creates time for the actual writing process. The most significant danger in using GenAI for finding sources is that it might hallucinate and the sources might be incorrect (Magesh et al., 2025). Sources provided by GenAI should always be verified as there is no GenAI research legal tool that is free of hallucination (Magesh et al., 2025).

3.4. Problem-Solving

Law students need to be equipped with problem-solving skills. Traditionally, clinical legal education has been used to expose students to real-life legal problems and scenarios. Moot courts and mock trials have also been used to expose students to court setups and protocols. However, law modules usually have a large amount of students and doing mock trials with large groups of students can be time-consuming. For this reason, virtual courtrooms (powered by AI) have been used by Law Faculties. The University of Johannesburg has designed a virtual courtroom that confronts students with real-life scenarios in courtrooms. During the development phase of AI-generated simulations, expert advice is usually sought after. This consultative phase addresses the tendency of GenAI products to provide false or irrelevant scenarios.

4. ETHICAL CONSIDERATIONS

4.1. Academic Integrity

It is of utmost importance that law graduates conduct themselves with ethical integrity. One of the biggest challenges associated with GenAI is the risks it poses to ethical behaviour. The biggest risk facing students is a lack of academic integrity. It is quite easy for students to submit an assignment question into GenAI and to submit an answer as is. Plagiarism has existed even before the arrival of GenAI. However, there is no completely reliable tool to detect the use of AI (Weber-Wulff et al., 2023). It should be noted that universities and institutions have differing policies on the extent to which GenAI can be used. Some universities ban it completely, while others encourage its use.

4.2. Bias and Fairness

Bias and fairness issues are also one of the ethical concerns related to the use of GenAI (Balan, 2024; Li et al., 2025). Li et al. (2025) notes that since societal biases already exist, it is likely that these biases will be reproduced in GenAI models as they rely on existing textual data. Li et al. (2025) further note that the most frequently reported cases of bias relate to gender, race, nationality and professional biases. Within the African context, an awareness of bias and fairness is crucial, as GenAI tools are often trained on Eurocentric and patriarchal data (Zuiderveen Borgesius, 2020; Mubangizi, 2024).

4.3. Privacy and Data Concerns

LLMs such as ChatGPT use publicly available data, data licensed from third parties, as well as data provided by users (Ye et al., 2024). Where personal data is used from any of the sources, breaches of personal data might take place either by reproduction of the data or breaches from 3rd parties (Ye et al., 2024; Feretzakis et al., 2024).

4.4. Legal Practice

In the South African legal fraternity, the existing framework has been used to regulate unethical behaviour in relation to the use of GenAI. The existing framework consists of the Ethical Code of Conduct. The Code of Conduct is issued in terms of the Legal Practice Act.

The viewpoints of the legal fraternity on the use of GenAI seem to be mixed. A few cases have dealt with the use of generative AI by legal practitioners in South Africa. In *Makunga v Barlequins Beleggings* (WCC) (unreported case no 19733/2017, 1-12-2023), a legal practitioner used GenAI to draw up his heads of argument. He had disclosed this fact to the court and the presiding officer commended the pleadings. In *Parker v Forsyth* (Johannesburg Regional Court) (unreported case no 1585/20, 29-6-2023), the attorney had sent a list of non-existing citations to the defendant before it was heard before a court. The citations were fictitious and it was found that ChatGPT was used. The court found that although there was no deliberate misleading of the court, that the parties were nevertheless “overzealous and careless”. The matter was reported to the Legal Practice Council.

In the second matter, *Mavundla v MEC: Department of Co-Operative Government and Traditional Affairs* 2025 (3) SA 534 (KZP), one of the parties before the court presented citations that were fictitious. The court referred to the duty on legal practitioners not to mislead the court. The presiding officer in this matter emphasised that technology should be used with independent reading. The presiding officer further emphasised that it remains the responsibility of legal practitioners to verify information that is used and if this is not done it is unprofessional. The matter was referred to the Legal Practice Council as well. In *Northbound Processing v Diamond Regulator* (2025/072038 ZAGPJHC 661), there was a similar case of fictitious cases found in pleadings. In the matter, the presiding officer referred the relevant parties to the Legal Practice Council.

In the abovementioned cases, the existing code of conduct was used to deal with the matter. It might be that disclosure would make a difference in how the use of GenAI is viewed. While it remains uncertain whether a code of conduct related to AI will be produced, it is encouraging to note that a group of legal practitioners and academics have proposed guidelines on the ethical use of GenAI in legal practice. The first guideline is integrity and diligence in the use of AI, meaning that practitioners should always check the relevance and accuracy of the information provided by GenAI. The second is the appropriate use of GenAI, which means that it should be used for routine tasks rather than substantive legal reasoning (Thaldar et al., 2025). Thirdly, independent critical thinking should not be sacrificed when using GenAI during legal research, the practitioner should always critically assess the information provided (Thaldar et al., 2025). Another guideline is that the use of GenAI should always be to the benefit of the client, which might mean charging a lower fee for increased efficiency (Thaldar et al., 2025). The working group also addresses disclosure, suggesting that there is currently not a need to disclose the use of AI as this might create the idea that the product provided has not done so responsibly (Thaldar et al., 2025). It might be that as the use of AI becomes more acceptable and common practice that disclosure could be expected in practice. Another guideline is that legal practitioners should also take care that the necessary protection against breaches of data and privacy are in place (Thaldar et al., 2025). Additional guidelines refer to bias and awareness of cybersecurity and staying up to date with the evolution of GenAI technology (Thaldar et al., 2025). These guidelines are currently going through a consultative process.

5. CURRICULUM REFORM FOR GENAI?

The discussion above, raises the question whether law curricula need to be reformed to deal with the challenges and risks posed by GenAI. Law graduates will be entering a working world where AI is already being used. In addition, as with other ethical dilemmas, there is the risk of using AI in an irresponsible manner. In South Africa, the LLB standards (Council on Higher Education, 2015) speaks to requisite skills and indicates the importance of ethical behaviour. The above-mentioned cases illustrate that existing principles on ethical conduct can be used.

However, the adoption of GenAI is still in its nascent stages which necessitates that Law schools will have to consider the skills that the next generation of law students need to be equipped with. It might be that students are in need of new skills, such as learning how to operate AI-operated search tools. In addition to technical skills related to AI, law students need to demonstrate an ethical awareness of the use of GenAI, in the working world generally, and more specifically in the legal practice. Having said that, law schools should not lose sight of the basic skills, that were taught prior to the advent of GenAI. These skills are still relevant to the practice of law.

Based on the above discussion, the following recommendations are made.

5.1. Policy Development

Firstly, universities should have a clear policy on the use of GenAI. The policy should not simply state that GenAI should be used ethically. Ethical use should be explained. It is recommended that GenAI policies should exist at different levels of universities. For example, while there might be a university policy, faculties should create more detailed and subject-specific policies, that are aligned with university policies. At the institutional level, policy should be created that ensures equitable access to the required hardware, software and technical support (Faber, 2024). It is suggested that law schools incorporate the ethical use of GenAI into courses on academic integrity, non-discriminatory use of GenAI and practices related to data protection. The LLB curriculum already contains objectives to ethical behaviour. It is recommended that the objectives on ethical behaviour be expanded to include ethical behaviour in relation to GenAI. Gutowski and Hurley (2025) recommend that law schools involve all relevant stakeholders when designing policy around GenAI. In the South African context, this would mean that professional bodies, such as the legal practice council should also be involved in policy design.

5.2. Mandatory Training

Secondly, all academic staff should be trained in the use and ethics of GenAI (Munir, 2025). Since it is encouraged that lecturers incorporate GenAI components into their coursework, it only follows that lecturers convey the correct policies to students. Faber (2024) maintains that it is important that future lawyers have AI literacy. Given the importance of being AI literate, it is recommended that lecturers and students take mandatory courses on AI literacy. Kong et al. (2021) propose that an AI literacy course for university students can have three basic components: (a) teaching basic AI components (b) using AI components for evaluation and (c) using AI for problem solving.

5.3. Hands on Activities in Class

Thirdly, as discussed above, the integration of GenAI into legal education offers various avenues for the enhancement of skills for future lawyers. The curriculum should specifically speak to the potential of GenAI tools to improve writing, research and problem-solving skills of law students. Eckart (2022) suggests that law students be exposed to GenAI writing tools in writing courses as early as the first year already.

At the same time, lecturers should give clear written instructions on the extent to which AI can be used. It is also recommended that GenAI be used in real time classroom settings before students do so independently. Students should be properly briefed on assignments related to AI and the risks of using AI (Bliss, 2024).

5.4. Diversification of Assessments

In the last instance, it is recommended that there be a variety of assessments including written, oral, formative, summative, online and in-person. While it is encouraged that the ethical use of GenAI be used, other assessments such as written tests can still be utilised.

It is important that the law curriculum reflects the ethical behaviour that will be required from students in the professional world. It seems as if the guidelines proposed by the working committee mirrors the required skills by students, namely critical thinking, research, writing and problem-solving.

6. CONCLUDING REMARKS

GenAI tools have infiltrated university and work life. In the short time that it has existed, it has been used exponentially. Law graduates will be required to be proficient in legal technologies in their professions (Farber, 2024). This paper has found that it is possible to use GenAI in a manner that enhances existing skills needs while also exposing students to the use of GenAI. It is recommended that assignments are used which are aimed at practicing skillful working rather than a blanket prohibition. Skills that can be enhanced include writing, research, problem-solving and critical and analytical thinking. It is imperative that law curricula incorporate courses that inform students of the ethical use of GenAI tools. While GenAI can perform tasks that previously only humans could do, it does not replace humans and GenAI cannot be used ethically without human oversight.

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Chapter # 23

CRITICAL THINKING DISPOSITIONS IN THE UNIVERSITY STUDENT POPULATION:

A narrative synthesis of the concept

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ABSTRACT

Experts in the field of critical thinking (CT) make a conceptual distinction between CT skills and dispositions. While CT skills are the cognitive abilities to think critically, CT dispositions are the ingrained habits and attitudes that motivate individuals to apply those skills in given situations. Despite the rapid growth of CT research over the past three decades, most work has concentrated on CT skills rather than dispositions. Hence, there is a lack of consensus on the dispositional dimension, specifically how it is measured and how it can be nurtured by educators. This chapter addresses how CT dispositions have been defined in the literature. A systematic review methodology was used to search Web of Science, Scopus and PsycINFO databases from 1988 to 2022. Of 1014 records screened, 63 met the inclusion criteria. Findings were synthesised to create a single conceptual framework comprising 26 distinct dispositions. While our framework shows strong alignment with previous models, it adds new knowledge by highlighting the role of affective components, such as empathy. The framework provides a unified basis for advancing research, assessment, and pedagogy for CT dispositions in education settings. Moreover, critical evaluation of current measurement instruments reveals limited coverage and highlights the need for more comprehensive tools.

Keywords: critical thinking, dispositions, systematic review, higher education.

1. INTRODUCTION

Critical thinking (CT) is widely regarded as a cornerstone of higher education, central to preparing students for academic success, professional competence, and civic responsibility. While the skills component of CT, such as analysis, evaluation, and inference, has received substantial scholarly attention, researchers have increasingly emphasised that skills alone are insufficient. The capacity to think critically is deeply influenced by dispositions. CT disposition refers to the inclination or tendency to engage in CT, characterised by specific attitudes and habits of mind that enhance reasoning and decision-making. These are tendencies to approach problems, decisions, and learning with open-mindedness, inquisitiveness, truth-seeking, and perseverance, among others. Without such dispositions, even individuals well trained in reasoning skills may fail to apply them when most needed (Facione, 1990; Ennis, 1996).

The growing recognition of dispositions as a core aspect of CT reflects a shift in educational philosophy. Early work in the 1990s distinguished between the processes of reasoning, the skills of CT, and the results or outcomes of CT, such as sound decision-making and effective problem-solving. Within this broader context, dispositions came to be seen as the motivational and attitudinal drivers that determine whether cognitive skills are enacted in

practice. An individual may be capable of evaluating an argument, for instance, but without dispositions such as truth-seeking or willingness to question assumptions, that skill may remain dormant. This interplay between ability and disposition has been likened to a "two-sided coin," both elements essential for authentic CT (Dwyer, 2017). The work of Dwyer and colleagues advanced the field by taking an innovative student-centred approach to co-produce a definition and a conceptual framework (Dwyer et al., 2014; 2017; Quinn et al., 2020).

Despite agreement about the importance of CT dispositions, Quinn et al. (2020) summarise challenges in integrating different perspectives on CT dispositions, notably definitional disparities between authors, a general lack of specificity in operational definitions, and probable conceptual overlap across individual CT dispositions. For example, seminal instruments such as the California Critical Thinking Disposition Inventory (CCTDI; Facione & Facione, 1992) operationalised seven broad dispositions. Other researchers, however, argued that these categories were either too narrow or too culturally situated, limiting their applicability in diverse educational settings (Ku, 2009; Halpern, 2014). In response, alternative measures such as Sosu's (2013) Critical Thinking Disposition Scale (CTDS) and Quinn et al.'s (2020) Student-Educator Negotiated Critical Thinking Dispositions Scale (SENCTDS) were developed, each proposing slightly different conceptualisations.

2. BACKGROUND

University students are at a pivotal developmental stage where higher-order thinking and decision-making skills are cultivated. Focusing on their dispositions provides context-specific insights into how educational practices can better nurture critical thinking for their academic and professional success (Dwyer et al., 2017). Given the rapid expansion of empirical studies on CT dispositions in the past three decades, there is a need for rigorous synthesis. To date, no review has comprehensively mapped the landscape of dispositions identified since the Delphi report (Facione, 1990). Previous reviews have either focused primarily on CT skills (Abrami et al., 2015) or on pedagogical interventions without addressing the conceptual foundations of CT dispositions (Lai, 2011a). As a result, researchers and educators face a fragmented picture, making it difficult to design curricula, interventions, or assessments that holistically address students' dispositional readiness for CT.

The present study seeks to address this gap by systematically reviewing the literature on CT dispositions. Through this review, we aim to make three contributions to the field. First, we briefly describe the body of work. Second, we create a unified conceptual framework of CT dispositions that consolidates the full range of CT dispositions proposed in the literature. Third, by evaluating established instruments in light of our unified framework, we highlight gaps in measurement, drawing attention to important traits that remain under-assessed. In doing so, this review responds to ongoing calls for a richer integration of dispositions into CT research and practice.

3. METHODOLOGY

This study adopted systematic review methods for the search strategy. Where appropriate, our reporting was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). However, risk of bias assessment and quantitative synthesis of effect measures were not relevant for our narrative-based synthesis.

3.1. Search Strategy

Three major databases of indexed journals (i.e. Web of Science, Scopus and PsycINFO) were searched. The goal of the search was to identify the articles that defined and described CT dispositions in the field of education, particularly higher education (university). Phrase searching with quotation marks and logical operators increased the precision of the search by narrowing results to exact matches, while truncation broadened the search by finding variations of a word stem. Search terms were limited to the title, abstract or keywords. One search syntax was defined as: ("critical think*" OR "think* critically") AND disposition AND (teach* OR learn*). The other was: ("critical think*" OR "think* critically") AND disposition AND (questionnaire OR survey OR instrument OR inventory OR index OR scale NOT validity). The full set of articles for screening included those identified by either search syntax. The search was conducted in March 2022.

3.2. Inclusion and Exclusion Criteria

Inclusion criteria were: 1) Work that defined CT dispositions along with the characteristics of the individual CT dispositions. 2) Work that reported participants recruited through university or participants aged at least 18 years. Work could be either empirical research or literature reviews or other theoretical articles.

Exclusion criteria were: (1) Work published before 01 January 1988 because 1988 was the date of a landmark study by Facione (published in 1990) which identified CT dispositions as separate from CT skills, (2) Work investigating CT dispositions in the context of a broader research question (such as how CT dispositions relate to academic performance, or how to enhance CT dispositions), 3) Work published as a conference proceeding, because this is often not peer-reviewed and so quality is less assured, 4) Work published as a book chapter, again for the same reason, 5) Work published in a non-English language because this was determined by the resources available within the research team, and 6) Studies reporting participants under the age of 18 years or high-school students or elementary-school students. Automatic filters were used to apply four of the exclusion criteria: (1) only articles published on or after 1988, (3 & 4) work reported in conference proceedings or book chapters, and (5) work published in a non-English language.

3.3. Screening and Selection Process

Study screening and selection consisted of two phases conducted independently by two of the co-authors (SF and DAH). In the first phase, the titles and abstracts of all retrieved articles were independently screened against the inclusion and exclusion to avoid selection bias. In the second phase, the full text of all remaining articles was reviewed for eligibility. Lastly, the reference lists from the selected records were also screened for potential articles that met the inclusion criteria. Rater agreement was 97% on study screening decisions, the remainder were resolved by mutual discussion, keeping in mind the objectives for this review.

3.4. Data Extraction

A structured data extraction spreadsheet in Excel was used to capture information consistently across records. Extracted data included: Year of publication; Country of study; Study type (quantitative, qualitative, mixed methods, conceptual/theoretical, review); Study setting (multi-discipline or single discipline); Description of the discipline; Study design (Cross-sectional, Longitudinal); Aims of the study; Sample size; CT dispositions identified or defined in the study (i.e. names and descriptions). Coder initials and article code (each article was given a code number) were also recorded.

Data was extracted independently by four coders: three of the co-authors (SF, RS, DAH) and one Psychology intern. SF extracted data for the full set of included articles. Simultaneously, RS and DAH each independently extracted data for half of the set. Coders focused on extracting the core content - specifically the names, descriptions and number of CT dispositions. The Psychology intern was responsible for collecting more straightforward bibliographic details, such as year of publication, country etc.

SF pooled the data extraction across coders and any inconsistencies were resolved by checking against the article. Data is available (Hall & Fathima, 2025).

3.5. Data Synthesis

A narrative synthesis approach was employed to capture how the CT dispositions were conceptualised and how the concepts were operationalised. Names and descriptions of CT dispositions identified from the literature were printed on individual paper cards to aid the process of synthesis. Synthesis used a card-sorting technique to help categorise the different names and descriptions into discrete CT disposition groups. This method is recognised as a valid technique to organise qualitative data, particularly in exploratory contexts where categories must emerge from complex data (Spencer, 2009). In educational contexts, this method encourages deeper reflection, shows how participants organise concepts, supports collaborative sense-making, and helps develop conceptual frameworks. Sorting was conducted in an office space with a large table. SF, RS, and DAH collaboratively grouped cards by conceptual similarity and negotiated differences of opinion until categories were agreed, and dispositions reported only once were discarded. Any dispositions that did not align with existing categories were temporarily grouped under a miscellaneous label and were later reassigned to the most suitable categories in the list. SF then reviewed the initial sort independently to consider refinements. Finally, the categories and their definitions were evaluated for clarity, shared with two co-authors (CPL, TL), who evaluated their clarity, coherence, and consistency against the original sources. Their feedback informed further refinement to ensure conceptual accuracy and reliability. The final conceptual framework represented our best efforts to synthesise the literature, identifying discrete CT dispositions that were supported by the body of published work. The Data is available for review (Hall & Fathima, 2025).

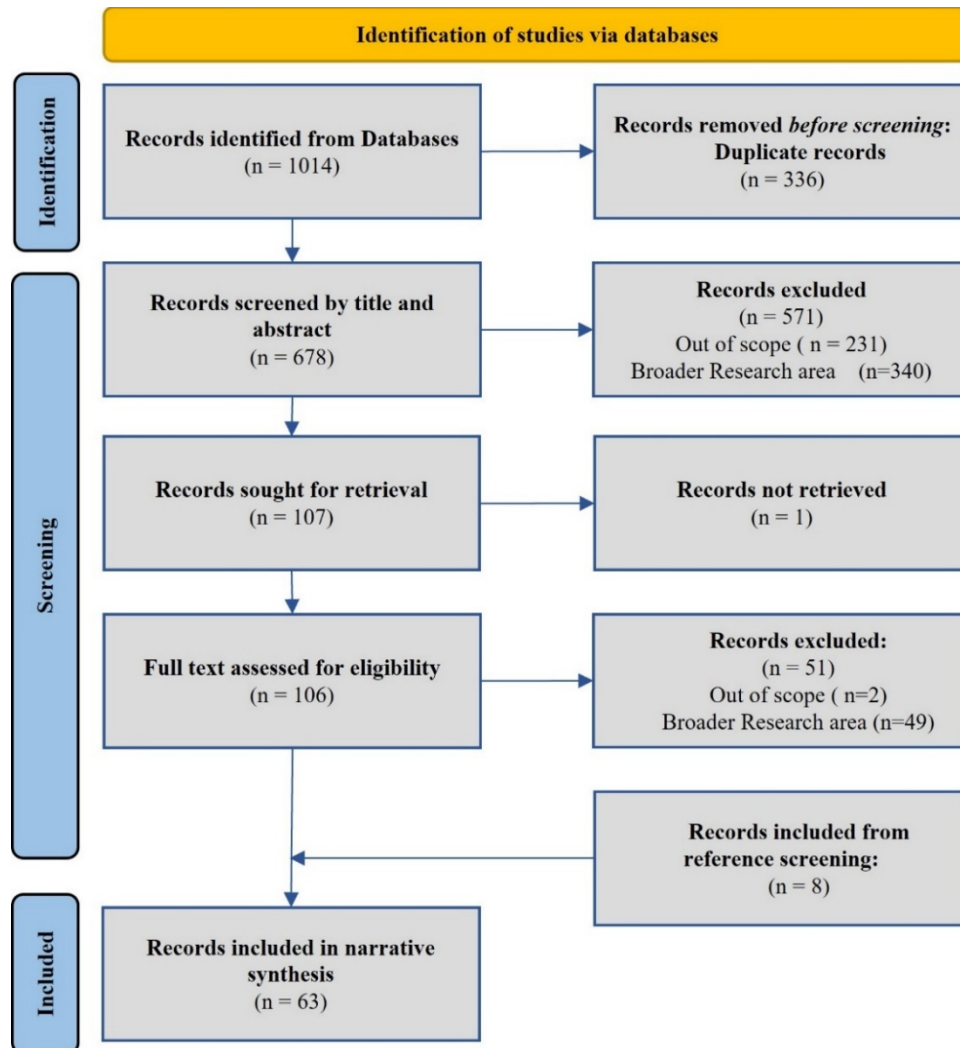
4. RESULTS

4.1. Selected Records

The flowchart in Figure 1 depicts the stages of the review process. A total of 1014 records were initially identified through the database searches. After removing 336 duplicates, 678 unique records remained for title and abstract screening. Of these, 571 were excluded due to being out of scope or addressing a broader research area. The most common reasons for exclusion under the category 'out of scope' were records that focused exclusively on the skills aspect of CT without addressing the dispositional component, as well as records involving participants under the age of 18, such as high school or elementary school students. For the 'broader research area' category, records were excluded if they primarily examined the relationship between CT and academic performance or explored general strategies for enhancing CT, without a specific focus on critical thinking dispositions. From the remaining 107 records, one record could not be retrieved in full despite efforts to obtain it through institutional access and interlibrary loan and was therefore excluded. Next, 106 records were assessed for eligibility using the full text screening and out of these 51 were excluded, mostly

due to the broader research area category. Additionally, eight relevant records were identified through reference list screening of the included full-text articles. These records were likely not captured by the initial search syntax because their titles, abstracts, or keywords did not explicitly mention the phrase ‘CT disposition’, even though the full texts included relevant data. A total of 63 records were included for narrative synthesis.

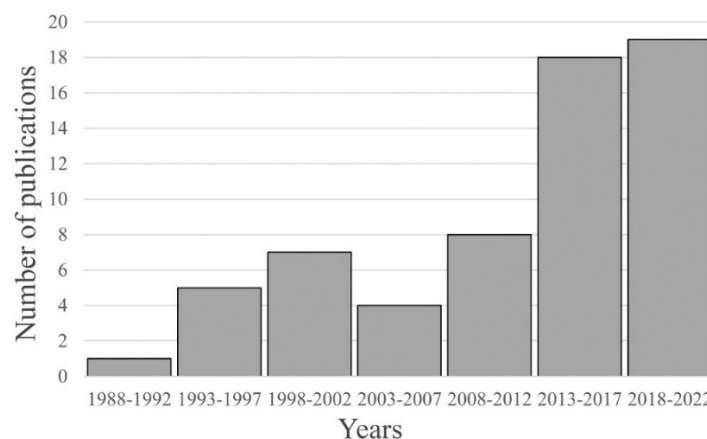
Figure 1.
PRISMA flowchart showing the search, screening and exclusion/inclusion of published work.



4.2. Characteristics of the Included Records

The 63 records comprised 38 quantitative and 7 qualitative empirical studies, 2 mixed-methods studies and 16 theoretical (conceptual) or review papers. There has been a steady growth in scholarly interest in CT dispositions as shown by the growth in publications, particularly in the last decade (Figure 2).

Figure 2.
Rise in publications addressing CT dispositions over time.



Of the 47 articles reporting an empirical study, the sample size varied widely (median=320). The smallest sample was 11 participants in a mixed methods study involving surveys and interviews (Raymond & Profetto-McGrath, 2005), while the largest sample included 1,557 nursing students in a quantitative study (Facione, 2000).

The records spanned a diverse range of disciplines, such as Education, Dental Medicine, Clinical Medicine, Physical Therapy, Psychology, Nursing, Pre-Service Teacher Training, Social Work, Educational Psychology, Teacher Education, Higher Education Teaching, Nutrition, and Behavioural Sciences. In addition, several records were interdisciplinary in nature, involving participants from multiple academic fields.

The majority of the empirical studies employed cross-sectional survey designs (n=44), reflecting a dominant reliance on questionnaires to measure CT dispositions. This approach is useful for its efficiency in gathering data from large samples and for identifying general patterns or associations. A smaller number of studies used interviews (n= 5), focus groups (n= 2) and observations (n= 3) to gain qualitative insights.

Scholarly work on CT dispositions has largely been dominated by the U.S.A. (43%, 27/63 records), followed by Europe (19%, 12/63 records). There were limited contributions from Asian, African and Pacific regions.

Figure 3.
Geographical distribution of research on CT dispositions
(contributing countries shaded in grey).



The number of total CT dispositions presented in each record varied considerably (median=5). The greatest number was 19 CT dispositions reported by nursing educators (Gordon, 2000).

4.3. Categories and Descriptions of Critical Thinking Dispositions

The data synthesis generated 26 distinct CT disposition categories (Table 1, Figure 4). Where possible, the names and descriptions were inspired by the work of Dwyer (Dwyer et al., 2017; Quinn et al., 2020).

Table 1.
Names and descriptions of the 26 CT dispositions within the unified conceptual framework.

#	Name	Description
1	Analyticity	The propensity to use logic and proof; to understand challenging circumstances; disposed to predicting negative effects; to be tactical and habitually well-planned; to gauge how one develops their arguments and their ability to anticipate potential roadblocks to problem solving; seek justifications and supporting evidence for beliefs, opinions, attitudes, arguments and ideas; to evaluate arguments, assumptions and perspectives critically; to restrain from irrational behaviour.
2	Attentiveness	To possess the willingness to focus and concentrate, coupled with an awareness of one's surroundings, the context, potential consequences, and possible obstacles; to see the situation in its entirety; to show a consistent interest in staying well-informed, being mentally alert, and directing focused attention toward the issue at hand.
3	Courage	To be daring and adventurous, to be ready to face challenges.
4	Creativity	A propensity for novel idea generation and visualisation; to think out of the box; to find creative ways to think and conduct,

		demonstrating criticality as a component of the creative thinking process with others.
5	Empathy	An inclination to respect each person's worth and dignity by learning about their perspectives, taking into account their feelings, and avoiding being judgmental; showing concern for others' well-being; to understand and acknowledge others' emotions.
6	Fair mindedness	A propensity for fair thinking and attitude; to be able to reason through complex ethical issues.
7	Flexibility	To be willing to look for alternatives, being adaptable when taking other perspectives into account; to resolve, re-address, and re-analyse complex situations using a variety of procedures to get a fresh perspective.
8	Inquisitiveness	A propensity to have curiosity; to possess a strong desire to fully understand something or to uncover the solution to a problem, even accepting that an answer might not be immediately apparent; to have a sustained interest in comprehending a task and its associated demands, available options and limits.
9	Intellectual honesty	The propensity to be honest in admitting one's own presumptions and biases; to strive to advance not only one's own but also others' ways of thinking; to question one's own assumptions.
10	Intrinsic goal orientation	A propensity to have a positive and enthusiastic attitude towards a task and the process of acquiring new knowledge; to be driven to find answers primarily by internal motivation, rather than by external rewards or incentives.
11	Learning to choose	The propensity to make a final decision that is presented in the oral or written way of reasoning, artistic or scientific form; valued as a personal disposition and for personal favour; to understand that critical choices are valuable in terms of proving one's ideas and actions in learning and daily life situations.
12	Need for cognition	A propensity to enjoy engaging in deep thought and working to complete cognitively complex tasks, a process that involves active thinking and rethinking; to modify routines and behavioural patterns for one's own benefit and the benefit of others.
13	Objectivity	The propensity to overcome personal prejudices and impartiality.
14	Open mindedness	The propensity to be flexible in cognitive thinking; to be able to resist rigid thinking; to consider and tolerate diverse or contradictory viewpoints; to set aside one's own biases and self-interests to genuinely consider perspectives different from their own; to be receptive to feedback, accepting positive comments and thoughtfully considering criticism or constructive suggestions; to be willing to update one's knowledge in light of new ideas and experiences; and to explore such new alternative or unusual ideas.
15	Perseverance	An inclination to being resilient and maintaining motivation when working through complex, frustrating, or difficult tasks, rather than giving up; to have the drive to complete tasks accurately and a sustained desire for progress.

Critical Thinking Dispositions in the University Student Population:
A narrative synthesis of the concept

16	Precision	The tendency to make thoughtful decisions after thorough consideration, to exercise intellectual caution, seek accuracy, to be precise about thinking.
17	Prudence/Maturity	A propensity to be prudent in forming, suspending, or modifying judgement; understanding that there may be several feasible options; to have an understanding of the necessity of coming to a conclusion even in the absence of comprehensive knowledge.
18	Recognise uncertainty	The tendency to accept doubt and uncertainty; to recognise one's own limited knowledge.
19	Reflection	The inclination to thoughtfully examine one's own behaviours, attitudes, beliefs and as well as the motivations behind them; to acknowledge the limits of one's current understanding and recognise uncertainty; to approach decision-making with the understanding that certain issues are complex and may have multiple reasonable solutions; to base judgments on thorough analysis and evaluation, considering feasibility, established standards, specific contexts and existing evidence.
20	Resourcefulness	The inclination to be ready to use existing resources to solve problems; to actively search for supplementary external resources when needed; to have the flexibility to shift between different problem-solving strategies or knowledge domains to discover new approaches or information; to make the most of available resources; to be able to adapt oneself and improve when challenges arise and critically analyse why or how something went wrong.
21	Scepticism	A propensity to question assumptions; to delay judgement before considering all the information; to establish a position and be prepared to change position when the evidence and reasoning are sufficient; to examine the findings from a variety of perspectives; to be critical towards newly encountered information; to have a tendency to doubt and recheck knowledge.
22	Self-confidence	The propensity to have a confident reliance on one's own reasoned judgments; to acknowledge one's personal context, such as life experiences, existing knowledge, biases, cultural background and environment, when evaluating problems and arguments; to be confident in one's ability to process feedback constructively; to confidently guide others towards rational problem resolution; to recognise that sound reasoning is fundamental to leading a rational life and developing a more equitable world.
23	Self-correction	The inclination to distance oneself from one's own convictions, self-awareness and mindfulness; to be willing to give up ineffective tactics in an effort to self-correct; to restrain from making judgments based on prior assumptions.
24	Systematicity	The disposition to carefully plan, classify, concentrate, and locate a propensity to attempt to tackle issues in a methodical manner with precision and discipline, the value of structure, attention, and assiduity in solving issues of all complexity levels, the propensity for gathering and using information to solve complex issues, the ability to carefully choose and employ reliable criteria for evaluation, search diligently for

		pertinent information, identify motives and suspend hasty conclusions.
25	Truth seeking	The inclination to have a genuine desire for knowledge; to actively seek and offer both supporting reasons and opposing arguments to become well-informed and to inform others; to be prepared to question widely held beliefs and social norms; to be honest and objective in their pursuit of truth, even when findings challenge their self-interest or existing convictions; to be willing to revise their views when new evidence emerges.
26	Valuing critical thinking	The disposition to be aware of the value of critical thinking.

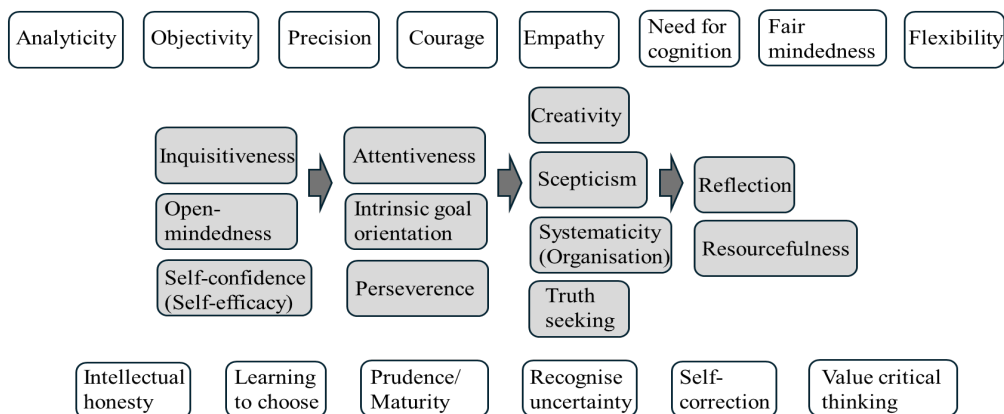
4.4. Evaluating the Unified Framework of CT Dispositions

To strengthen its theoretical basis, our unified synthesis of CT dispositions was compared with Dwyer et al.'s (2017) framework. Our synthesis of the literature confirmed 10 of Dwyer's CT dispositions (Figure 4, grey shaded boxes), while two others (i.e. systematicity/organisation and self-confidence/self-efficacy) had reasonable conceptual equivalence, but with naming differences. Systematicity reflects structured, disciplined engagement with information and problem solving, while self-confidence reflects faith in one's own reasoned judgments. This widespread commonality indicates good conceptual consistency across the field in how CT dispositions are construed. While Dwyer's category of clarity (Dwyer et al., 2017) was not directly retained, its conceptual meanings were subsumed under the alternative constructs (i.e. truth-seeking and intellectual honesty).

Despite these similarities, other scholars have identified other important habits or attitudes. Our synthesis highlighted 14 additional CT dispositions which captured cognitive, affective/motivational and metacognitive dimensions not recognised in Dwyer's framework (Figure 4, white boxes).

Figure 4.

Comparative evaluation of the unified conceptual framework of CT dispositions. Dispositions in grey shaded boxes confirm the same constructs as Dwyer et al. (2017). Here they are arranged in putative antecedent and succedent interdependencies following Dwyer et al. (2017). Dispositions in white boxes expand on other important habits of mind reported in the published literature.



4.5. Evaluating the Unified Framework of CT Dispositions against Established Measurement Instruments

To address whether existing measurement instruments completely represent the entire concept of CT dispositions, we examined the subscales of the CCTDI (Facione & Facione, 1992), SENCTDS (Quinn et al., 2020), and CTDS (Sosu, 2013). Table 2 highlights the relatively limited content validity between instruments. The CCTDI measures seven dispositions, the CTDS measures two dispositions, and the SENCTDS measures six dispositions. Only open-mindedness is measured by all three instruments, while many dispositions are absent.

Table 2.
Comparative mapping of the 26 CT dispositions on the instruments.

#	Name	CCTDI (Facione & Facione, 1992)	CTDS (Sosu, 2013)	SENCTDS (Quinn et al., 2020)
1	Analyticity	✓		
2	Attentiveness			✓
3	Courage			
4	Creativity			
5	Empathy			
6	Fair mindedness			
7	Flexibility			
8	Inquisitiveness	✓		
9	Intellectual honesty			✓
10	Intrinsic goal orientation			
11	Learning to choose			
12	Need for cognition			
13	Objectivity			
14	Open mindedness	✓	✓	✓
15	Perseverance			✓
16	Precision			
17	Prudence/Maturity	✓		
18	Recognise uncertainty			
19	Reflection			✓
20	Resourcefulness			
21	Scepticism		✓	
22	Self-confidence (Self-efficacy)	✓		
23	Self-correction			
24	Systematicity (Organisation)	✓		✓
25	Truth seeking	✓		
26	Valuing critical thinking			

5. FUTURE RESEARCH DIRECTIONS

One of the limitations of this work is that the 26 CT dispositions do not necessarily represent distinct constructs. For example, open-mindedness is defined as the inclination to think in a flexible way (a stable personality trait), while flexibility is more about willingness to look for alternatives (motivation). Halpern (2014) defined flexibility as a unique disposition, while Dwyer et al. (2017) merged this into open-mindedness. This lack of clear conceptual definition creates significant challenges for measurement. Three instruments which purport to measure CT dispositions fail to capture the full multi-dimensionality of the concept. This finding highlights the need for a new tool that is not only more comprehensive in scale but is also psychometrically robust. We recognise the challenge in meeting this need. For example, SENCTDS was created from an initial pool of 167 scale items spanning 13 CT dispositions. Nevertheless, poor results for structural and convergent validity eliminated seven of those 13 dispositions (Quinn et al., 2020). Factor analysis demonstrated significant cross-loading which is indicative of conceptual overlap. Until that need is better met, current instruments remain psychometrically inferior, limiting efforts to build a holistic profile of students' CT dispositions and weakening the ability of educators to cultivate well-rounded critical thinkers. Our findings clarify the breadth of CT dispositions. Meaningful progress would be made if scholars could identify which of these 26 CT dispositions are conceptually distinct. This in turn could guide the development of measurement tools that have better psychometric properties.

We believe that a more comprehensive understanding of CT dispositions can not only inform students' assessment but also shape their teaching and learning. Another valuable research direction would therefore be to design learning environments that recognise antecedent and succedent interdependencies between CT dispositions (Dwyer et al., 2017) and are effective in fostering them (Loyens et al., 2023). For example, with respect to a broad developmental sequence for learning, we may look to Dwyer's analysis of putative interdependencies between CT dispositions (Dwyer et al., 2017). Although their findings from focus group discussions and interpretive structural modelling are preliminary, results suggest that inquisitiveness, open-mindedness and self-efficacy are foundational for CT, while reflection and resourcefulness seem to be more highly dependent on the influence of other CT dispositions (see Figure 4). A logical pedagogical recommendation would therefore be for students to first gain mastery of inquisitiveness, open-mindedness and self-efficacy, before practicing reflection and resourcefulness. Moreover, 'later maturing' dispositions tend to draw on numerous habits of mind. For example, resourcefulness has meta-cognitive elements (e.g. flexibility to shift strategies), affective elements (e.g. (confidence, persistence) and motivational features (e.g. willingness to search for resources).

6. DISCUSSION

Our unified framework builds on Facione's (1990) anchor and comprises cognitive, affective/motivational and metacognitive dimensions. By drawing on both empirical and theoretical studies spanning a wide range of disciplines such as nursing, medicine, and teacher education, it provides a comprehensive, universal framework of 26 CT dispositions. To our knowledge, this is the first rigorous synthesis of the literature on CT dispositions in university students using replicable research methods (Page et al., 2021) and comparing the findings to previous conceptual frameworks (Dwyer et al., 2017; Facione, 1990).

The identified dispositions are grounded in complementary theoretical perspectives. Virtue epistemology frames them as stable intellectual character traits oriented towards knowledge and understanding (Baehr, 2011). From the perspective of Motivation theory (Ryan & Deci, 2020), dispositions such as inquisitiveness and intrinsic goal orientation help explain why individuals are willing to initiate and sustain engagement in effortful cognitive work, particularly in complex or uncertain contexts. Metacognition research (Lai, 2011b) highlights how dispositions such as reflection and self-correction enable learners to monitor and regulate their thinking. Together, these perspectives show why these dispositions matter for learning and intellectual development.

The review shows a degree of geographic concentration, with most studies conducted in Western contexts, which may limit the cultural generalisability of the identified dispositions. Restricting the review to English-language publications may have excluded relevant studies in other languages. Synthesis decisions such as consolidating overlapping constructs and grouping conceptually similar dispositions required interpretive judgment. While these decisions may limit exhaustiveness, they also strengthened conceptual clarity by reducing redundancy and enabling coherent categorisation.

A number of the CT dispositions (e.g. courage, creativity, empathy) are often missing from CT disposition lists in early literature. This is because early research focussed on a relatively cognitive, logic-oriented conception of CT; with associated popular measurement instruments such as CCTDI (Facione & Facione, 1992). Dispositions such as creativity and empathy do not fit neatly into this schema. For example, good creative ideas are not necessarily logical or practical, so while creativity can support CT, it needs to be applied alongside CT and with care for it to be effective. Delving more deeply into the reasons for the omission goes beyond the scope of this book chapter, but interested readers are signposted to Dwyer et al. (2017).

Empirical evidence from employer expectations indicates that dispositions are differentially emphasised across disciplines (Cruz et al., 2021). In STEM (Sciences, Technology, Engineering and Mathematics) field, greater emphasis is placed on analyticity, inquisitiveness and systematicity. Health-related disciplines, such as Biomedicine, emphasise truth-seeking, empathy, maturity and scepticism. In the Social sciences, inquisitiveness and maturity are particularly salient, whereas the Humanities place greater weight on analyticity, open-mindedness, and creativity (Cruz et al., 2021).

While the debate on whether CT is generic (Siegel, 1988; Davies, 2013) or domain-specific (McPeck, 1981; Moore, 2011) is ongoing, contemporary research adopts an intermediate view, treating CT as broadly applicable but shaped by disciplinary norms, since standards of evidence and reasoning vary across knowledge fields (Abrami et al., 2015). This position is particularly salient for CT dispositions. For instance, deficits in empathy disposition carry different professional implications in nursing as compared to engineering. These considerations point to the value of a critical-thinking-across-the-curriculum approach, in which academic departments identify priority dispositions, embed them within authentic disciplinary tasks and assessments, and reinforce their development longitudinally (Ennis, 2013). Given that dispositions are partly implicit, their assessment should triangulate validated instruments with performance-based evidence and reflective justification. Equally important, faculty play a central role in making dispositional norms visible by modelling practices such as intellectual honesty, openness to alternatives, and reasoned scepticism, while explicitly linking these habits of mind to disciplinary standards and professional practices (Facione et al., 1995).

Overall, efforts to nurture CT in higher education should address not only cognitive skills, but also the dispositional foundations that motivate and sustain critical engagement across diverse and challenging contexts. We would argue that teaching transfers better when dispositions are cultivated alongside skills. Embedding these dispositions within the curriculum further is anticipated to better prepare students for lifelong learning, equipping them with adaptable habits of mind to evaluate, synthesise, and apply knowledge in ways that can foster innovation, inform decision-making, and facilitate meaningful contributions to society.

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Chapter # 24

EXTENDING THE 2D3S4L FRAMEWORK: Generative AI for pedagogy, literacy, and cross-cultural English classrooms

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ABSTRACT

This chapter presents the 2D3S4L instructional model, designed to embed generative chatbots into secondary English classrooms with pedagogical coherence. The model aligns teaching and learning processes across two dimensions (teachers and students), three stages of instruction (pre-class, in-class, post-class), and four recursive loops (analyze, design, implement, evaluate). Grounded in sociocultural theory and the TPACK framework, the model was implemented in Chinese secondary schools using DeepSeek and Doubao AI to support writing, speaking, and reflective reading tasks. Findings show chatbots enhanced idea generation, linguistic accuracy, and learner autonomy, while teacher prompts and scaffolded feedback were critical for effective integration. Concrete examples illustrate how chatbots facilitate task execution and deepen reflection. The chapter provides a structured framework, as well as practical guidance, on what future AI-enhanced language instruction might look like. The chapter provides not only a structured framework but also concrete suggestions for what new AI-enhanced language instruction may be for educators in the future. These initiatives set up both theoretical foundations as well as practical approaches toward the impactful implementation of AI in language learning.

Keywords: 2D3S4L instructional model, generative chatbots, AI-enhanced language learning, secondary English education, TPACK framework.

1. INTRODUCTION

AI (Generative artificial intelligence) has opened great opportunities in the context of English language instruction; AI offers advanced language-learning capability, creativity, and the ability to take advantage of new situations in real time. It provides learners with real-time interaction, idea scaffolding, and language refinement, as with tools such as DeepSeek and Doubao AI. It is symbolic of a broader trend in language teaching itself: in the age of AI, students can now turn to automation in every step of the learning process from practice to assessment – vocabulary drills, grammar exercises, and much more. Nevertheless, the existing research (Wang & Dang, 2024) suggests that there is less clarity among teachers on how to ensure that the pedagogical potential of AI is maximized. Notwithstanding these affordances, there is no clear-cut approach to implementing AI in secondary classrooms and it has been reported that the use of AI practices is superficial. In the absence of guidelines, students will likely turn to chatbots as their “answer calculators” not dialogue partners, and teachers urgently need conceptual tools to ensure that chatbot capacity and instructional objectives are the same. To address this gap, this chapter introduces the 2D3S4L model—a structured approach to pedagogically embed chatbots into language instruction. The model integrates two core actors (teachers and students), three temporal stages (pre-class,

in-class, post-class), and four recursive design loops (analyze, design, implement, evaluate). Grounded in sociocultural theory and the TPACK framework, it enables intentional design and adaptive use of generative AI in classroom practice.

This study explores how generative chatbots can support task-based English instruction through the 2D3S4L model. There are 3 main research goals: (1) to create a theoretically based and pedagogically relevant design framework; (2) to demonstrate explicit teaching applications in writing, speaking and reading tasks; and (3) to analyze the influence of chatbots on student autonomy, language growth, and metacognitive reflection.

To ensure transparency and rigor, this study adopted Braun and Clarke's (2006) six-phase thematic analysis approach: familiarization, initial coding, theme generation, theme review, theme definition, and final reporting. Data analyzed included over 60 student artifacts, 18 student interviews, and 6 teacher observation logs. All interviews and observation notes were transcribed verbatim. Student artifacts (e.g., written texts, chatbot interaction records, annotated drafts) were anonymized and categorized by task type and grade level. An initial coding framework was developed based on Braun and Clarke's (2006) thematic analysis approach, with open coding conducted during the familiarization phase. Two researchers independently coded a subset of data to calibrate consistency, followed by iterative refinement through discussion. Discrepancies were resolved through negotiated agreement. All remaining data were then manually coded using the agreed framework, with emergent themes identified inductively across the three task types. NVivo software was used to organize codes, support constant comparative analysis, and ensure transparency in analytical decisions.

This study employed a design-based research (DBR) methodology to develop and refine the 2D3S4L model in authentic classroom settings. Design-based research enables iterative, real-world intervention while maintaining theoretical grounding (Wang & Hannafin, 2005). The study involved three public secondary schools in China, comprising six English teachers and approximately 120 students across Grades 7 to 9. Teachers participated in a pre-study workshop covering chatbot tool usage, prompt design, and pedagogical alignment strategies. Tasks were co-constructed by researchers and teachers to embed chatbot interactions into curriculum-based learning goals. Three task types were implemented: opinion writing, tourist role-play speaking, and reflective reading. Chatbot use occurred throughout all instructional phases: idea activation, drafting, revision, feedback provision, and post-task reflection. Data included student texts, chatbot transcripts, classroom observations, and post-task interviews. A thematic analysis approach identified patterns in language outcomes, student attitudes, and pedagogical adaptations.

Two chatbot platforms with differentiated functions were utilized. DeepSeek was primarily employed for writing and reflection tasks, valued for its elaborative and coherent textual output. In contrast, Doubao AI supported spoken interactions, offering real-time pronunciation and fluency feedback suitable for dialogic practice. While this study did not include a formal control group, learning gains were inferred from pre- and post-task comparisons, supported by triangulated data from student self-reports, teacher observations, and rubric-based assessments.

2. BACKGROUND

The 2D3S4L model is grounded in two core theoretical frameworks. First, sociocultural theory (Vygotsky, 1978) emphasizes the role of social interaction and mediated tools in learning. In this model, the generative chatbot is viewed as a semiotic tool that scaffolds learners cognitive and linguistic development through dialogic engagement. Second, the

Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006; Koehler & Mishra, 2009) provides a structure for integrating AI tools into curriculum design, ensuring that technology use supports both content mastery and pedagogical aims (Mishra, Warr, & Islam, 2023). These two perspectives collectively inform the structure of the model and guide its classroom implementation.

Additionally, the 2D3S4L model can be contextualized within broader technology integration theories. One widely used model is SAMR (Substitution, Augmentation, Modification, Redefinition), which describes stages of technology integration from substitution to redefinition (Puentedura, 2020). From a SAMR perspective, chatbots initially act as simple substitutes—for example, replacing a dictionary or grammar checker. As teachers design more purposeful prompts, chatbots shift into augmentation and modification roles, enriching pre-class brainstorming or reshaping in-class dialogues. At the highest level of redefinition, students treat AI as dialogic partners, engaging in collaborative meaning-making beyond what traditional classroom resources can achieve.

Similarly, Bloom's Revised Taxonomy has been adapted to AI contexts. Generative chatbots not only support remembering and understanding by providing quick definitions or examples but also encourage higher-order thinking such as analyzing arguments and creating original texts (Anderson & Krathwohl, 2001). Within this taxonomy, the 2D3S4L model provides a pathway for moving learners systematically from lower-order to higher-order thinking in AI-supported classrooms.

The concept of AI literacy adds another critical perspective (Chandel & Lim, 2024). Students need not only technical proficiency but also the capacity to critique AI output, detect bias, and consciously decide whether to adopt or reject suggestions. By embedding reflection across all three stages of instruction, the 2D3S4L model naturally fosters AI literacy alongside language learning.

To further clarify the unique value of the 2D3S4L model, the following table compares it with the SAMR model and TPACK model in terms of theoretical positioning, application scenarios, and core advantages:

Table 1.
Comparison of the SAMR Model, TPACK Model, and 2D3S4L Model.

Theoretical Framework	Theoretical Positioning	Application Scenarios	Core Advantages
SAMR Model	Descriptive framework for stages of technology integration	Functional positioning of technology in teaching	Clearly defines the hierarchical evolution of technology application
TPACK Model	Framework for integrating technology, pedagogy, and content	Teacher knowledge structure and curriculum design	Emphasizes the collaborative application of three-dimensional knowledge
2D3S4L Model	Pedagogical integration framework for AI	Dual-subject (teacher-student) interaction and the full teaching process	Balances theoretical support and practical operability; integrates metacognitive reflection and cross-cultural adaptation

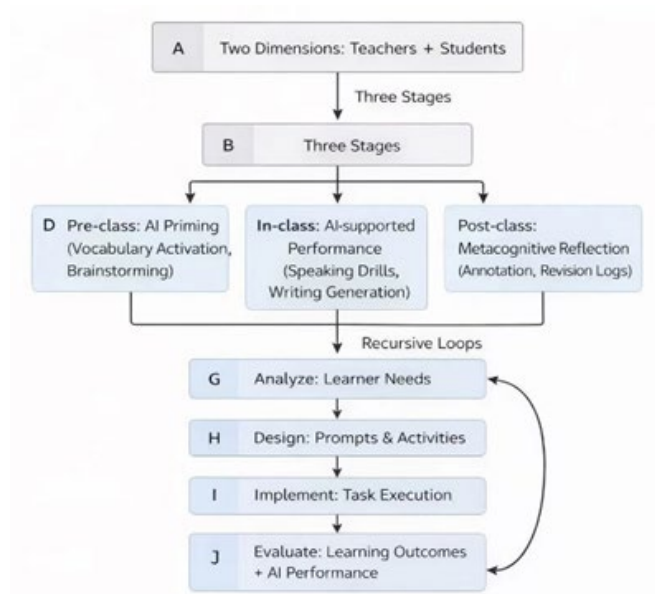
Compared to the SAMR model, which focuses on describing technology application levels, the 2D3S4L model places greater emphasis on the systematic integration of teacher-student interaction and the full teaching process. In contrast to the TPACK model, which centers on teacher knowledge structure, this model further refines the implementation pathways of AI tools in specific teaching links, supplements metacognitive reflection

mechanisms and cross-cultural adaptation dimensions, and addresses the limitations of existing frameworks in practical guidance and contextual adaptability.

This section supplements relevant foundational research literature to strengthen theoretical support: Hui (2024) explores the role of Bloom’s Taxonomy in promoting cognitive thinking mechanisms in AI-supported learning environments. Hmoud and Shaqour (2024) propose the AIED Bloom’s Taxonomy, providing a model for enhancing educational efficiency and effectiveness in the AI era. Chiu et al. (2024) construct a comprehensive framework for AI literacy and competency, offering guidance for related teaching practices. Additionally, Hofstede’s (2011) cultural dimension theory is supplemented to lay the foundation for subsequent cross-cultural comparative analysis.

3. THE 2D3S4L INSTRUCTIONAL MODEL

Figure 1.
2D3S4L Model.



The 2D3S4L model consists of three core layers. First, the two dimensions: (1) teachers as designers and facilitators; (2) students as autonomous language generators. Second, the three stages: (a) pre-class AI priming (e.g., vocabulary activation, brainstorming); (b) in-class AI-supported performance (e.g., speaking drills, writing generation); (c) post-class metacognitive reflection (annotation, revision logs). Third, the recursive instructional loops – analyze learner needs, design chatbot prompts and activities, implement tasks, and evaluate both learning outcomes and chatbot behavior. Unlike tool-specific methods, 2D3S4L is platform-agnostic. Teachers adapt prompt complexity and chatbot roles to learner levels. The model views chatbots not as replacements for instruction but as dynamic tools that support negotiation of meaning, feedback literacy, and voice development.

3.1. Explanation of Technical Limitations

The generative AI tools used in this study have certain technical boundaries: first, the risk of data bias—tools such as DeepSeek and Doubao AI are primarily trained on resources from the English-speaking world, with a Western perspective bias, which may lead to expressive bias in cross-cultural contexts; second, fluctuations in the accuracy of generated content—occasional incorrect outputs may occur on professional topics or complex grammatical structures, requiring teachers to guide students to critically evaluate them; third, functional adaptation limitations—while DeepSeek’s text generation function is suitable for writing tasks, it lacks real-time oral interaction feedback capabilities, and Doubao AI’s oral support still has room for improvement in dialect accent recognition; fourth, privacy and security risks—the cloud-based interaction model may involve issues related to the storage and use of students’ learning data, requiring compliance with relevant ethical norms and data security policies.

3.2. Implications for Different Age Groups

Grade 7 (Lower Secondary): Students at this stage have weak cognitive levels and language foundations. It is recommended to use AI tools for low-order tasks such as basic vocabulary activation and simple sentence pattern generation. Teachers should design more specific prompts and reduce the proportion of open-ended questions; focus on preventing mechanical copying, add specialized paraphrasing training, and help students integrate AI output through visual templates.

Grade 8 (Middle Secondary): The complexity of tasks can be appropriately increased, and AI can be used to support interactive tasks such as role-playing and topic discussions; focus on cultivating students’ ability to apply feedback, guide students to compare differences between their own expressions and AI suggestions, and encourage personalized adjustments on the basis of imitation; teachers need to strengthen the deconstruction guidance of AI-generated structures to avoid mechanical application by students.

Grade 9 (Upper Secondary): Focus on cultivating higher-order thinking skills, and use AI tools to carry out tasks such as reflective reading and critical writing; encourage students to design prompts independently and actively explore the auxiliary functions of AI; focus on cultivating AI literacy, guide students to identify the biases and limitations of tools, and conduct cross-cultural comparative analysis combined with multiple resources.

4. CLASSROOM IMPLEMENTATION AND CASE EXAMPLES

4.1. Opinion Writing Task

In this task, students used chatbots for reference summary and idea mapping during pre-class preparation. Teachers designed scaffolded prompts and later encouraged students to annotate and reflect on AI-generated feedback. As a result, many students’ drafts showed improved fluency and cohesion. However, there was a common problem: some learners directly copied phrases generated by chatbots in their responses without contextualization, which led to subsequent lessons on paraphrasing and maintaining one’s own voice.

Teacher Strategy: Prompted prewriting with DeepSeek, and assigned post-task reflection.

Outcomes: Improved writing fluency and structure.

Challenges: Overreliance on copied phrases from chatbots.

Grade 7 students were assigned the task "My Favorite Season." Pre-class, the teacher crafted a prompt in ChatGPT that helped students generate outlines with reasons, examples,

and vocabulary banks. During class, students expanded the outlines into full drafts with AI feedback on transitions, sentence fluency, and paragraph coherence. Post-class, they annotated chatbot edits, justifying revisions or rejections. While writing quality improved, several students copied phrases without contextual adaptation. Teachers responded by guiding discussions around language ownership and added a follow-up activity requiring students to rephrase chatbot suggestions in their own words. The task also emphasised the model's reflection phase, fostering metalinguistic awareness and critical engagement with AI suggestions (Eisenring et al., 2024).

One Grade 7 case has served to highlight a few advantages and some drawbacks. At first, a student only made three basic sentences: "I like spring. The weather is good. The flowers are beautiful." After exploring DeepSeek, the student then elaborated this further and structured a paragraph with transitions: "I like spring because it is the season of rebirth. The weather is warm but not too hot, and flowers make the parks colorful. I can go play outside with my friends in a light shirt." The improvement in coherence was apparent, but the "season of rebirth" part was a direct borrowing from the chatbot. To tackle this, the teacher initiated a short lesson on paraphrasing that required students to restate AI-generated ideas in their own words, for example, "spring makes everything come alive again." This practice reinforced the balance between using AI as a prompt and keeping one's own voice intact.

4.2. Tourist Role-Play Speaking Task

For the speaking task, students interacted with Doubao AI to simulate tourist dialogues. The AI provided real-time feedback on pronunciation and sentence fluency. Teachers scaffolded these performances by reviewing recordings with students and highlighting moments of linguistic creativity. While the activity raised learner confidence, there was also a risk of imitating AI-generated structures, particularly for less confident learners.

Grade 8 students used Doubao AI to simulate tourist dialogues. Pre-task vocabulary review was followed by in-class chatbot interactions focused on giving directions and handling questions. Chatbot feedback included pronunciation correction and real-time fluency suggestions. Teachers observed increased confidence but also noticed mimicry of AI structures. Post-task recordings were reviewed by students to evaluate conversational tone and complexity. In one case, a student modified AI-suggested sentences to include idiomatic expressions, demonstrating linguistic personalization. The teacher emphasized that AI outputs are scaffolds, not scripts, and required students to reflect on what made their version stronger or more authentic.

One example was of a Grade 8 student who relied heavily on AI structures when giving directions, often repeating phrases exactly as suggested. In response, the teacher introduced a "prosody contrast" in which students compared their AI-influenced recordings with authentic human dialogues from travel podcasts. Looking at these differences in rhythm, intonation, and phrasing, they moved from mechanical mimicry to more natural speaking. Post-task reflection logs showed that learners became more aware of their own voice and expression, underscoring the need for teacher intervention in shifting AI from a crutch to a catalyst.

4.3. Reflective Reading Task

In the reading task, students engaged with chatbot-generated responses to questions about Mandela's biography. They were then encouraged to judge, alter, or extend the chatbot's answers through writing journal entries and peer reviews. This gave rise to considered reinterpretations and deeper personal engagement. Still, some students initially

accepted the chatbot's optimism uncritically, highlighting the need for explicit instruction in critical reading and stance formation.

In one Grade 9 activity, the teacher added a "stance matrix" to support deeper reflection. Students categorized AI responses as optimistic, critical, or neutral, and then justified their classification. For example, when DeepSeek answered the question "What would Mandela advise modern leaders?" with an overly positive response emphasizing forgiveness, some students placed it in the "optimistic" column but added comments noting that Mandela also advocated political resistance. This small adjustment allowed learners not only to read AI content but also to engage in perspective-taking; it helped them practice critical literacy beyond basic language learning.

Grade 9 learners also engaged with Mandela's biography and used DeepSeek to explore questions like "What would Mandela advise modern leaders?" Students then edited, questioned, or extended the chatbot's replies. Most AI-generated answers portrayed an upbeat attitude, but some students went against the grain and incorporated broader sociopolitical contexts.

One teacher commented that "the AI helped launch discussions, but the real depth came from disagreement." This task illustrated the chatbot's role as a dialogic partner, not an authority. It activated reflective reading and interpretation, with students refining their stances through post-task journaling and peer review.

Table 2.
Comparative Summary of AI-integrated Tasks.

Task Type	Student Use	Teacher Strategy	Outcome	Challenge
Opinion Writing	Generate outline, vocabulary	Prompt design + revision reflection	Improved fluency	Copying AI phrases
Role-Play Speaking	Dialogue with AI, pronunciation feedback	Scaffold performance + playback	More confidence	Structural mimicry
Reflective Reading	Debate AI interpretation	Journaling + peer review	Stronger critical thinking	Adopting AI views uncritically

4.4. Reflective Reading Task

Thematic analysis revealed four recurring themes across the three tasks and grade levels. These themes captured students' cognitive, emotional, and behavioral engagement with chatbot-supported learning (see Table 3).

Table 3.

Theme	Description	Sample Evidence	Frequency
AI as Confidence Booster	Chatbots lowered students' anxiety and encouraged language risk-taking.	"It doesn't laugh at my mistakes." (G8 student)	Reported by 13 of 18 interviewed students
Surface Dependence on AI Output	Students initially copied AI-generated text without personal adaptation.	Copied 'Spring is the season of rebirth...' from chatbot.	Found in 9 of 20 early writing samples
Importance of Teacher Scaffolding	Structured prompts and modeling led to better AI engagement.	Revised 'Mandela was a great leader' into more nuanced version.	Observed in all 3 classrooms
Reflection Promotes Personalization	Post-task reflection led to critique and deeper understanding.	"The AI missed the political side." (Student journal)	Found in 10+ annotated journals

4.5. Empirical Evidence on the Impact of Learner Motivation

Quantitative data indicate that AI tools have a positive impact on learner motivation: in post-task surveys, 78% of students stated that "interacting with AI makes English learning more interesting," and 65% believed that "real-time feedback enhances learning achievement." Longitudinal observations found that after 8 consecutive weeks of using the model, the frequency of students' active participation in classroom interactions increased by an average of 42%, with the most significant improvement in speaking tasks. Wang and Dang's (2024) systematic review also confirm that generative AI can effectively enhance the intrinsic motivation of L2 learners through functions such as immediate feedback and personalized support; supplementary data from this study show that this motivation improvement is more pronounced among low-intermediate level students. However, teachers need to guide to avoid "motivation decay"—approximately 15% of students experienced decreased novelty after 4 weeks of use, requiring task design innovation (e.g., cross-cultural comparison tasks) to maintain engagement.

5. TEACHER PERSPECTIVES AND PROFESSIONAL DEVELOPMENT

Teacher interviews further revealed three domains of professional development essential for AI integration. Firstly, prompt crafting was cited as a pedagogical skill: instead of writing instructions in isolation, teachers learned to code prompt sequences that scaffold a task, for example, "Generate three possible introductions" → "Explain the strengths and weaknesses of each" → "Select one and adapt it for your essay." Second, they stressed a need for competence to interpret AI outputs: teachers confessed they had trouble discerning between fluency and accuracy in the output, writing that what "sounds right" isn't always grammatically or contextually correct. Third, teachers formed strategies to combat students' excessive reliance on the devices, like establishing classroom directives (rephrase twice each

time) or requiring AI corrections on the part of students. Here, the result suggests that teacher training must not be confined to the technical coaching of performance improvement goals. It has to promote new kinds of professional judgment and agency.

6. CROSS-CULTURAL AND COMPARATIVE INSIGHTS

Although the model was piloted in Chinese schools, the portability of the model also introduces some opportunities and challenges. In student-centered teaching methods prevalent in Europe, however, chatbots can act as peer buddies more than as authoritative educators.

In low-resource contexts, AI access may be uneven; offline or lightweight models could adapt the 2D3S4L framework by emphasizing pre- and post-class reflection more heavily than in-class real-time use. In multilingual settings, chatbots raise questions of linguistic hierarchy: should English dominate, or can chatbots scaffold translanguaging by supporting multiple languages?

Based on the comparative analysis above, subsequent applications must also consider prevailing cultural attitudes toward new technologies. In some East Asian classrooms, for instance, students were sometimes hesitant to ask questions that challenged AI outputs — part of a broader cultural value that respects authority. By contrast, Scandinavian students were less intimidated by or even mocked chatbot replies—a measure of their centuries-old traditions of dialogic learning. It shows how 2D3S4L is not a rigid mathematical model but a fluid blueprint which needs some cultural calibration. Teachers, therefore, need to explicitly communicate with their students that AI is not an absolute authority nor an insignificant toy but a mechanism for co-creation by everyone. Moreover, the model provides space for global dialogue: what mechanisms—prompts, practices of reflection, ethical safeguards—could teachers across distinct contexts share? And these cross-cultural exchanges can be a bridge toward innovative equity in an international adoption of educational AI.

7. ETHICAL, POLICY, AND INSTITUTIONAL ISSUES

There were other ethical considerations, too. Chatbot capabilities at times were received at face value and not scrutinized critically, raising concerns over AI literacy. Cloud-based platforms also have privacy concerns over information storage. Ethical frameworks from bodies like UNESCO (2021) and the OECD (2024) stress the importance of transparency, informed consent, and equitable access when AI is used in educational contexts. Furthermore, tools must be thoroughly examined before being adopted on campus, and AI's responsibility and reliability in learning contexts need to be discussed collectively and seriously. Building on this discussion, three more aspects require emphasis. First, bias and cultural representation: many chatbots are trained primarily on data from the English-speaking world, with a Western focus. This bias can also sideline other perspectives. Teachers should speak directly to students about it, for example, by comparing chatbot answers with sources from their own country or with non-Western texts. Second, institutional responsibility: individual teachers can model ethical practice, but sustainable implementation will demand school-wide policies on data storage, parental consent, and equitable access. Third, AI as a third-party reviewer: students referred to AI “as neither teacher nor classmate” in several classes, allowing them an unusual freedom with which to criticize its shortcomings. This raises an encouraging field for further work: digital literacy education, which helps students take algorithmic collaborators as partners, not just accept their outputs.

8. DISCUSSION

The findings suggest that the 2D3S4L model can support meaningful chatbot integration in secondary English classrooms. Students across all tasks were observed to use chatbots for brainstorming, extending the writing process, and reviewing written work. This aligns with recent research showing that generative AI improves writing verbosity and accuracy while posing a potential threat to learner voice (Wang & Dang, 2024). Teachers served as AI mediators—designing prompts, interpreting outputs, and helping students reframe responses. The cyclical structure promoted feedback literacy and learner agency. Though lacking a control group, progress was gauged through pre- and post-task trends and triangulated data.

In addition to qualitative reflections, selected student work was rated using a standardized rubric (adapted from CEFR writing descriptors). Among 24 writing samples, 18 showed improvements of at least one band level in coherence and lexical range, with average writing scores increasing from 3.1 to 4.2 (out of 5). In oral tasks, peer-assessed fluency ratings improved for 72% of participants. Post-task surveys indicated that 86% of students agreed AI feedback helped them notice weaknesses in their argumentation or organization.

Most interestingly, a small minority of participants (3 out of 24) improved only minimally with full access to AI tools. Secondary interviews indicate underlying factors such as digital unfamiliarity, lack of motivation, and passive engagement. This emphasizes the importance of a dynamic induction, ongoing teacher monitoring, and a well-timed scaffolding mechanism.

A further implication emerging from the study concerns classroom culture. Where teachers actively normalized critique of AI outputs, students displayed stronger ownership of learning. In contrast, classrooms that treated AI as a "silent assistant" saw more copying and surface-level engagement. This suggests that effective integration is not simply about technical access but about cultivating norms of inquiry and dialogue. Another implication relates to peer collaboration. Several groups of students began spontaneously discussing the limitations of chatbot responses—such as vague topic development or unnatural phrasing—and collectively revised them. This demonstrates how AI can become a third participant in triadic dialogue (student-peer-machine), enriching collaborative meaning-making. Future iterations of the 2D3S4L model could make such triadic engagement an explicit design feature.

However, success depended on metacognitive scaffolding. Without explicit post-task analysis, students risked copying AI-generated structures. Metacognitive scaffolding is essential to help learners internalize AI suggestions rather than reproduce them mechanically (De Amicis, 2025; Barkley & Major, 2024). Classroom norms and feedback tasks played a vital role in transforming chatbot use from passive assistance to co-construction. The model itself demonstrated adaptability over different language abilities as well as in various grade levels, indicating its utility in scaffolded language learning contexts. Meanwhile, when AI takes on the role of co-participant in the classroom, careful pedagogical approach is necessary.

Within reported classrooms, learners used, questioned, and adapted AI output. This tripartite interaction—between students, peers, and machines—signifies a shift toward shared meaning-making. At an institutional level, this evolution requires teacher training, cross-departmental collaboration, and policy support for sustainable practice.

8.1. Possibilities for Interdisciplinary Collaboration

The deep integration of AI and language education requires interdisciplinary collaboration: language teachers can partner with AI technical experts to develop prompt templates and tool functions tailored to teaching needs; work with education policy experts to formulate ethical norms and data security standards for classroom AI application; and collaborate with educational psychologists to design teaching strategies for enhancing students' AI literacy. Taking the Erasmus+ program as an example, transnational and interdisciplinary teams can share model application experiences across different cultural contexts to optimize the framework's cross-cultural adaptability. At the school level, English teachers, IT teachers, and moral education teachers can jointly develop school-based "AI + language teaching" courses that integrate language competence, technical literacy, and ethical awareness.

9. CONCLUSION

The 2D3S4L model provides a robust framework for integrating chatbots in language teaching with pedagogical coherence. It aligns technology with student needs and reflective learning cycles. Classroom implementation examples across all three task types demonstrate the model's flexibility and potential to promote fluency, autonomy, and independent thinking. Future research should address the following directions: longitudinal impact of the model, differentiated analysis of student-AI interaction patterns, and exploration of the method's application in translanguaging teaching; meanwhile, continued emphasis should be placed on specialized teacher training in prompt design and AI critique.

By extending previous conference findings into this book chapter, this study has moved from presenting a model to constructing a roadmap for practice. The background literature review situates the 2D3S4L model within a broader theoretical framework; 11 expanded cases reveal two student characteristics not addressed in earlier research; and combined with the latest research progress, six out of seven cautions are newly added. Collectively, these outcomes demonstrate that AI integration does not mean replacing teachers: generative chatbots themselves are not solutions to any problems, but an element in the ever-evolving learning ecosystem where students, teachers, and machines co-construct meaning. Enhancing teachers' capacity in prompt design and AI critique through targeted training remains essential for effective integration.

10. LIMITATIONS AND ETHICAL CONSIDERATIONS

10.1. Research Limitations

Data and sample size were limited and the geographical scope of this study may limit the findings. Not all schools that have digital access or cultural contexts may likely share these findings. The novelty of AI may have also temporarily increased student motivation, but its long-term effects should be further examined. Moreover, while data triangulation was used, the coding was by researchers steeped in the Chinese educational environment, suggesting interpretive bias. Levels of English proficiency of students differed from class to class, which may have affected the depth of engagement with the chatbot. Such constraints may constrain the applicability of these findings and suggest that replication in different educational settings is warranted.

10.2. Ethical and Social Impacts

In addition to a challenge to individual performance, the model promoted a collective dialogue about AI. Students frequently mentioned the inadequacy of chatbot options for research, like unclear topic development or odd use of phrasing, and we collectively worked to improve on them. It placed AI as a third-party reviewer, neither teacher nor peer, and created both critique and imagination. Such interactions illustrate developing AI literacy and the importance of engaging in critical digital citizenship in education. Another key insight pertains to the agency of teachers. Chatbots offered consistent feedback, but it was the teacher's involvement — through prompt design, scaffolding and interpreting feedback — that converted AI interaction into genuine learning opportunities. Teachers observed that modeling a process for asking probing questions and negotiating AI-generated output encouraged students to move beyond superficial dependence. Ultimately, the model gave teachers the power to reframe AI as not a substitute for, but a co-facilitator within a highly orchestrated learning environment.

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Chapter # 25

THE COMBINED USE OF CONCEPT MAPS AND THE KAHOOT GAMING TOOL FOR A STRUCTURED TEACHING OF TELECOMMUNICATIONS

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ABSTRACT

The chapter presents the combined use of concept maps and the Kahoot gaming tool in the teaching of telecommunications. Concept maps were used for the presentation of the overall telecommunication subject through core concepts such as signals, transmission techniques, links, networks/services and market issues aiming at the students forming a well-structured overview of the telecommunication subject. At a second level, map elements were correlated to illustrate essential features of specific telecommunication applications. Kahoot, on the other hand, was used to help students visualize specific complicated topics such as electromagnetic propagation and signal transmission through optical fibers, the rationale being that visualization would help the students better comprehend the subsequent mathematical analysis. Kahoot was also used by the students to self-check the knowledge obtained by means of concept maps. The described approach was applied in the framework of telecommunication courses at the Department of Electrical & Electronic Engineering Educators, School of Pedagogical & Technological Education (ASPETE), Athens, Greece with the aim the students to develop technological and pedagogical content knowledge in accordance with the TPACK framework. The teaching process was evaluated through of two short questionnaires, the answer to which showed that the applied approach was successful and well received.

Keywords: electronic engineering education, concept maps, gaming tools, Kahoot, telecommunications, fiber-optics.

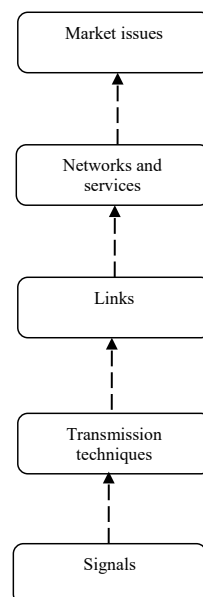
1. INTRODUCTION

Telecommunications is a very broad, multiple-topic subject intersecting with scientific fields such as mathematics, physics and informatics and this can be seen in most relevant textbooks (e.g., Taub & Schilling, 1986). Owing to that fact, students often feel confused when it comes to define certain telecommunication sub-fields or identify possible relations between telecommunication topics, the situation becoming more difficult since several of those topics may be overlapping and/or interrelated. However, despite the complications with regard to the teaching of telecommunications, the relevant literature is rather limited, especially when it comes to deal with the telecommunications subject as a whole.

With the aim to address the above issue and help students develop a clearer and well-structured overview of the telecommunication domain, a teaching model was proposed (Pagiatakis, 2005) that includes six modules with the preceding modules serving as the background for the subsequent ones and the latter providing the former with application

examples. A modified layer-structured version of this model, that includes five modules, is shown in figure 1. From bottom to top, those modules are (i) signals, (ii) transmission techniques (digitization, modulation and multiplexing), (iii) link types (cable, terrestrial wireless, satellite, optical), (iv) telecom networks and services (dial-up, data, broadcasting and broadband services) and (v) market issues (mainly regarding the deregulated framework of the present telecom market). Taking the conventional telephony of the recent past (the most notable dial-up service) as an example, the application of this model in a top-to-bottom manner would result in stating that telephony was provided through the telephone network (with the information routing procedures being based on the so-called “circuit switching” technique) with the network comprising all types of links (cable, optical and, in some cases, wireless) and each link employing the appropriate transmission techniques (digitization, modulation and multiplexing) to transmit the voice signals. It has to be noted that the described approach can be used for either delivering a single overall course on telecommunications or developing a whole syllabus on telecommunication engineering (Pagiatakis et al, 2010).

Figure 1.
A layered model for the teaching of telecommunications.



Apart from the overall addressing of the telecommunication subject, there are certain difficulties and complications when it comes to the teaching of specific telecommunication topics. For example, electromagnetic propagation and signal transmission through optical fibers present several challenges to educators and students, mainly due to the complicated (and time-consuming) mathematics involved (the solution of the wave equation subject to specific boundary conditions) and the difficulty in associating mathematics with actual facts regarding the transmission process (e.g., Ming-Kang Liu, 1996). Even if a student is competent enough to follow the solution of such a problem, most probably he/she will find him/herself “lost in mathematics”, unable to connect mathematical results with how an

optical fiber actually supports and affects the transmitted signals. A similar situation has been observed with regard to the analysis of microwave waveguides and antennas due to the difficulty in handling Maxwell equations in combination with the appropriate boundary and/or far-field conditions.

The present article describes the combined use of concept maps and the Kahoot gaming tool with the aim to mitigate the above-mentioned difficulties regarding the teaching of telecommunication. More specifically, concept maps were used for the students to form a well-structured overview of the overall telecommunication subject and the inter-relation between the various telecommunication sub-fields while Kahoot focused on rather specific topics (such as the ones described above) that commonly cause difficulties to students mainly due to the complicated mathematics involved.

A concept map is a diagram that illustrates and helps build relations between concepts. As a notion, concept maps were first introduced by J.D. Novak in the early 1980s based on the idea that meaningful learning is greatly influenced by students' prior knowledge (Novak & Gowin, 1984; Novak, 1991; Stoica, Moraru, & Miron, 2011). One common form of concept maps is the one that includes a hierarchical organization of concepts with the more general concepts placed at the top of the diagram and the more specific ones at the bottom of it. Another form (which is the one used here) presents the concepts from left (more general ones) to right (more specific ones). Gamification on the other hand and its application to education (e.g., Disheva et al., 2018) has been associated with the enhancement of students' motivation and engagement which results in the educational process becoming more attractive and efficient (Lee & Hammer, 2011; Chapman & Rich, 2018). In this framework, the Kahoot gaming tool, which is a mobile-device application with a usable free version, lends itself for being embodied in engineering courses to facilitate the visualization of complicated concepts in an easy and user-friendly manner.

The use of concept maps regarding telecommunication teaching (limited, however, to signal transmission techniques) was described by Pagiatakis et al. (2024) while Freeman & Urbazewski (2002) used concept maps in a rather different context, that of assessing students' understanding of telecommunications. In this article, the use of concept maps was extended to help students develop a well-structured overview of the overall telecommunication subject (in combination with the layered model mentioned above) and also, through the proper correlation of individual map elements, to identify essential features of specific telecommunication services and applications. The Kahoot gaming tool, on the other hand (<https://kahoot.com/>; Voudoukis, Mantzios, & Pagiatakis, 2021), was used for the visualization of electromagnetic propagation and signal degradation phenomena in optical fibers (a specific topic with significant mathematical complexity) and, in addition, for the students to self-check the knowledge that was obtained with the aid of concept maps.

2. OBJECTIVES

As mentioned above, the difficulties associated with the teaching of telecommunications mainly stem from the broad and complicated structure of the overall telecommunication subject as well as the complex mathematics involved in the analysis of certain telecommunication topics such as the electromagnetic propagation and signal transmission either wirelessly or through optical fibers. Given the above-mentioned facts, the main objectives of the combined use of concept maps and Kahoot were:

(a) To help students obtain a clear and well-structured overview of the overall telecommunications subject. This was attempted by using concept maps in combination with the layered model shown in figure 1. At the first level, concept maps were used with regard

to core telecommunication concepts and processes such as signals, transmission techniques, links, networks/services and market issues. At the second level, the individual map elements were interconnected with the aim to identify essential features of specific telecommunication services and applications.

(b) To assist students in visualizing complicated telecommunication processes (e.g., electromagnetic propagation and signal transmission through optical fibers) prior to their mathematical treatment. The rationale was that the visualization of those processes through a gaming tool such as Kahoot) would make them easier for students to approach (even in a rather practical manner) which, in turn, would facilitate the comprehension of the subsequent mathematical analysis.

3. METHOD

The framework for the described teaching approach is shown in figure 2. As mentioned above, this framework anticipates the use of concept maps for the students to view telecommunications in a rather general manner (and also identify possible interrelations between the various telecommunication topics and features) and the employment of the Kahoot gaming tool for focusing on rather specific topics that commonly cause difficulties to students mainly due to their complicated mathematical analysis.

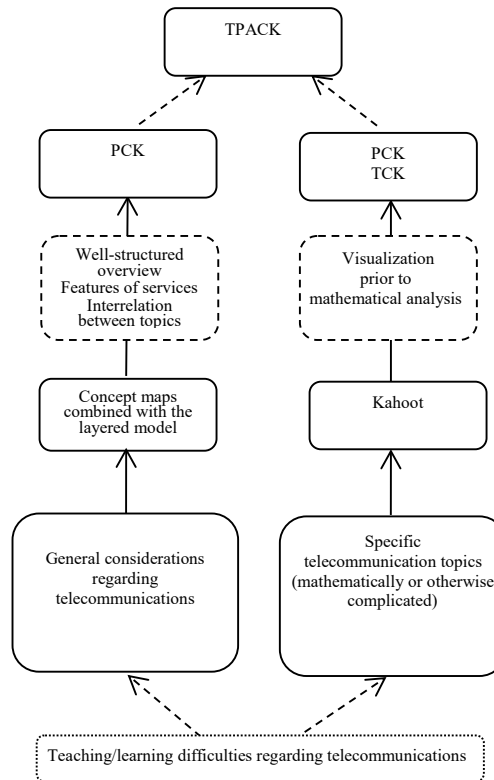
With regard to the use of concept maps, the applied approach anticipated two levels: At the first level, concept maps were used in a rather conventional way for the presentation of the overall telecommunication subject. More specifically, concept maps were used to illustrate the various types of signals, transmission techniques, types of links as well as communication network and services. The main aim was the students to outline and form a sound overview of the overall telecommunication subject which is broad and consisting of several often-overlapping topics. At the second (and more constructive) level, students were asked to correlate elements of the individual concept maps in order to identify specific telecommunication applications. This was the level where active participation of students was mainly sought.

As far as the Kahoot gaming tool is concerned, visualization was achieved by using Kahoot's free version since it is readily available and can be easily embodied in an engineering course. The basic rationale regarding the use of Kahoot for the presentation of electromagnetic propagation and signal transmission through optical fibers was that, if the students had first developed a qualitative grasp of the associated processes and mechanisms through visualization, this would help them follow the subsequent mathematical analysis as well as enhance their comprehension and practical aptitude, necessary for handling actual fiber-link problems. Active participation of students was sought and mainly achieved through the answering of relevant multiple-choice questions in an interactive manner.

The presentation that involved concept maps took place during a two-teaching-hour lecture in the framework of the 5th-semester "Telecommunication Systems" course (an introductory course on communication principles) in autumn 2023. The lecture took place at the end of the above-mentioned course in order the students to have encountered basic telecommunication concepts and processes. Kahoot, on the other hand, was used during five two-teaching-hour lectures in the framework of the 6th-semester "Optical Communications" course (spring 2024). Both courses are offered at the Department of Electrical & Electronic Engineering Educators of the School of Pedagogical & Technological Education (ASPETE), a tertiary educational institution, located in Athens, Greece. A unique feature of ASPETE is that its graduates, apart from working as engineers in their respective field, can be also employed as teachers in technological secondary schools (that is why the students, in parallel with their engineering courses, also attend courses on pedagogy, psychology and didactics).

The potential employment of ASPETE's graduates as school teachers is the main reason why particular emphasis is given to the students developing a conceptual and not just procedural understanding of the concepts and processes of their field. It is also essential the students to go beyond the primary forms of knowledge (content, pedagogical and technological knowledge) and build combined knowledge components as defined in the TPACK framework (Mishra & Kohler 2006). Taking that into account, the combined use of concept maps and Kahoot aimed at the students develop Pedagogical Content Knowledge (PCK) and Technological Content Knowledge (TCK) and, eventually, Technological Pedagogical Content Knowledge (TPACK). Regarding Bloom's revised taxonomy, on the other hand (Armstrong, 2010), the combined use of concept maps and Kahoot mainly regarded layers 2 and 3 (understand and apply) and maybe layer 4 (analyze).

Figure 2.
The framework for the combined use of concept maps and Kahoot
in the teaching of telecommunications.



4. DESIGN

4.1. Use of Concept Maps (and Kahoot for Self-Checking Purposes)

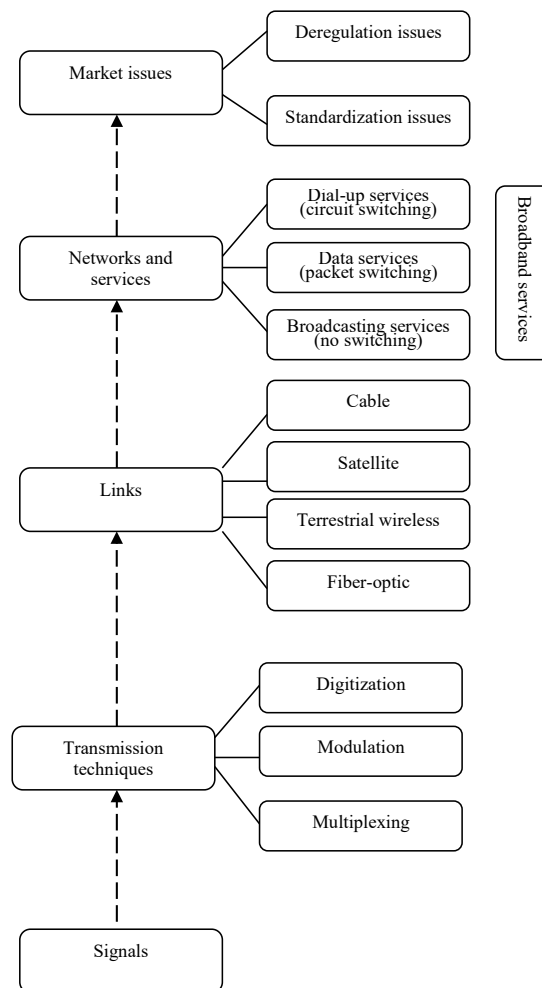
The use of concept maps in the relevant two-hour lecture included two parts:

In the first part, concept maps were used to outline the telecommunication subject as a whole. In this part, concept maps were combined with the layered model of the overall telecommunication subject (figure 1) as illustrated in figure 3.

In the second part, the students were asked to correlate elements of the individual concept maps in order to identify essential features of specific telecommunication services and applications. For example, the amplitude modulation (AM) and frequency modulation (FM), that are elements of the concept maps for transmission techniques, were associated with the wireless terrestrial links (element of the concept maps for links) to make reference to the radio broadcasting service while the phase-shift-keying (PSK) modulation technique combined with satellite links made reference to the satellite TV service. Other examples could be the association of certain transmission techniques (e.g., digitization and amplitude shift keying –ASK–) and certain link types (cable and fiber-optic) with telephony and data services as well as the association of requirements for basic transmission parameters (such as the bit rate, the bit error rate –BER– and the transmission delay) with telecommunication services such as telephony, data transmission and broadcasting (figure 4).

Figure 3.

The use of concept maps (first part): Concept maps are used in combination with the layered model for the teaching of telecommunications.



Self-checking of students was attempted by means of the Kahoot gaming tool. Indicative screenshots are shown in figure 5.

Figure 4.
The use of concept maps (second part): Concept maps are used to identify essential features of certain telecommunication applications and services.

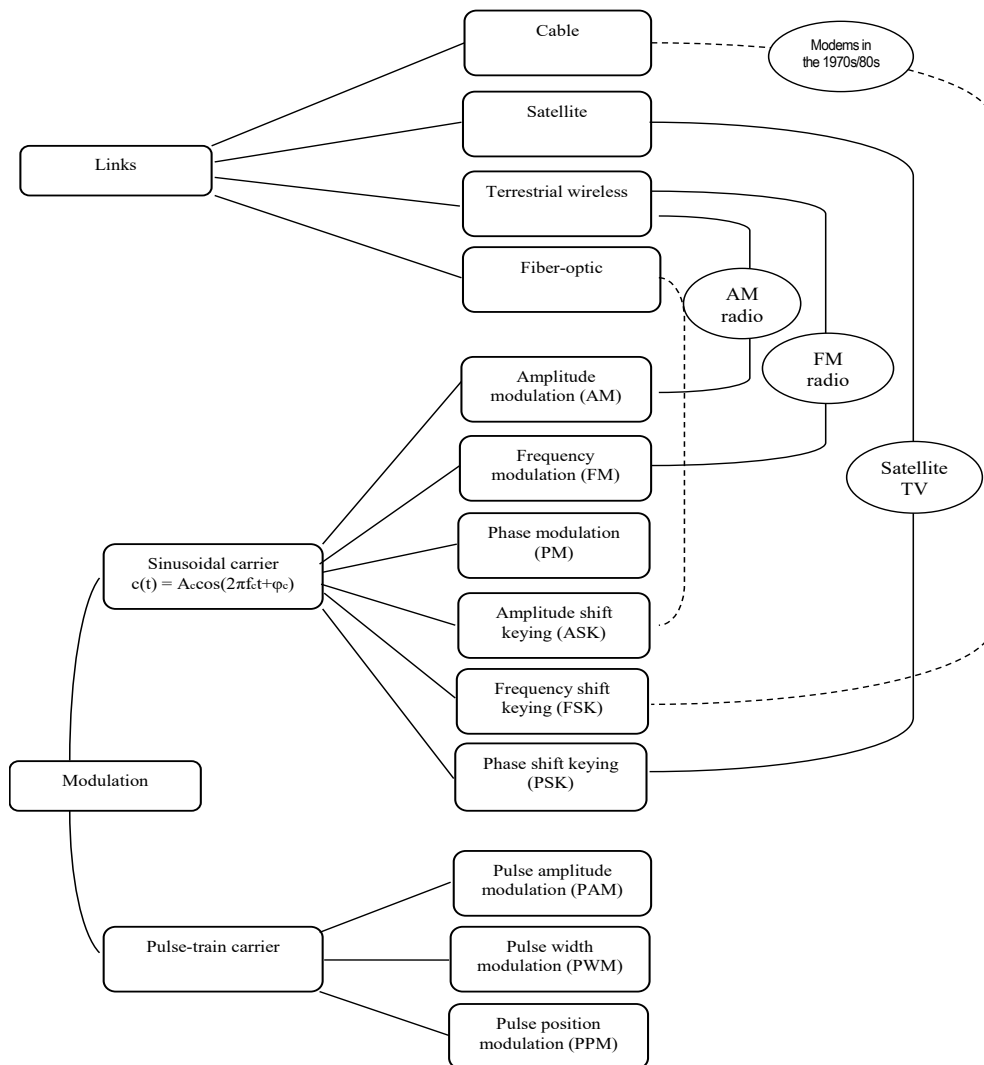
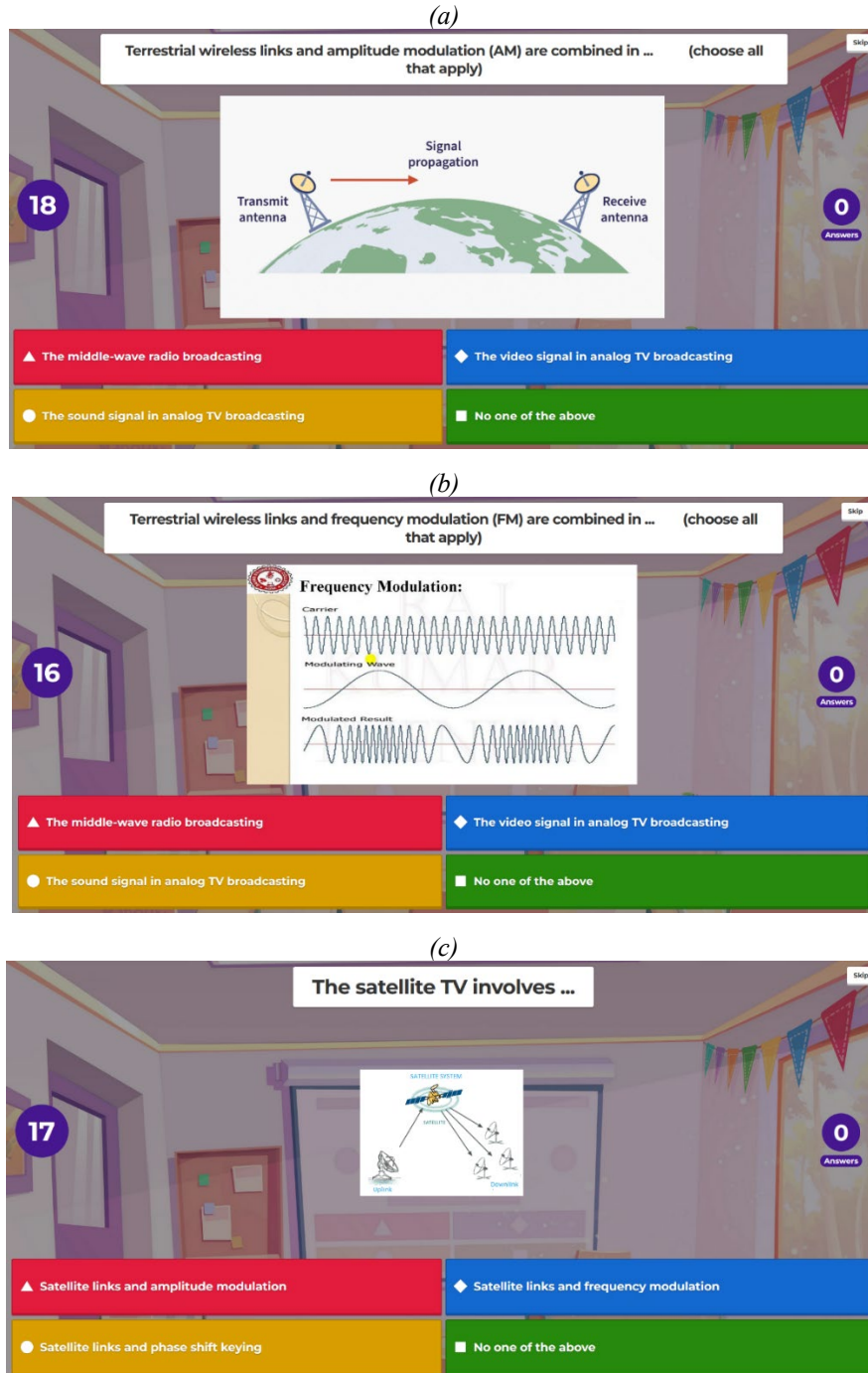


Figure 5.
Indicative Kahoot screenshots for the students' self-checking regarding knowledge obtained with the aid of concept maps.



4.2. Use of Kahoot (for Visualization Purposes)

The main use of Kahoot regarded the visualization of electromagnetic propagation and signal transmission through optical fibers prior to the relevant mathematical analysis. The presented content was divided into two parts, the first one dealing with electromagnetic propagation (with emphasis to the notion of propagating modes) and the second one dealing with signal degradation mechanisms, particularly attenuation and dispersion. Typically, the first part requires the solution of the wave equation (combined with the appropriate boundary conditions) in cylindrical coordinates and it is the topic that causes most difficulties and misunderstandings among students. The second part is the consideration of the fiber as a transmission medium and the analysis of signal degradation processes such as attenuation and dispersion.

Lectures 1 and 2 were about electromagnetic propagation while lectures 3 and 4 addressed signal transmission (table 1). Visualization through Kahoot was an essential element of those lectures and, all in all, it took about half of the teaching time. Indicative screenshots regarding the above lectures are shown in figure 6 while indicative additional questions are given in table 2. The last lecture was dedicated to a discussion on the content of the preceding lectures.

*Table 1.
Lectures on the electromagnetic propagation and signal transmission through optical fibers.*

Lecture	Topic	Objective	Topics to be presented and discussed (indicative list)
1 & 2	Electromagnetic propagation through optical fibers	The students to comprehend the basic mechanisms and processes regarding electromagnetic propagation through an optical fiber.	• Visualization of the concept of propagating modes. • Visualization of the dispersion diagram. • Practical issues. • Association with the solution of the relevant boundary-value problem (wave equation combined with boundary conditions).
3 & 4	The optical fiber as a transmission medium	The students to comprehend the transmission properties of optical fibers and the phenomena and parameters regarding signal attenuation and dispersion.	• The attenuation process. • The dispersion process (with emphasis to chromatic dispersion visualized by means of Kahoot).
5	Discussion	To evaluate the effectiveness of the applied approach through student feedback and quantitative assessment.	

Figure 6.
Indicative Kahoot screenshots regarding electromagnetic propagation and signal transmission through fibers.

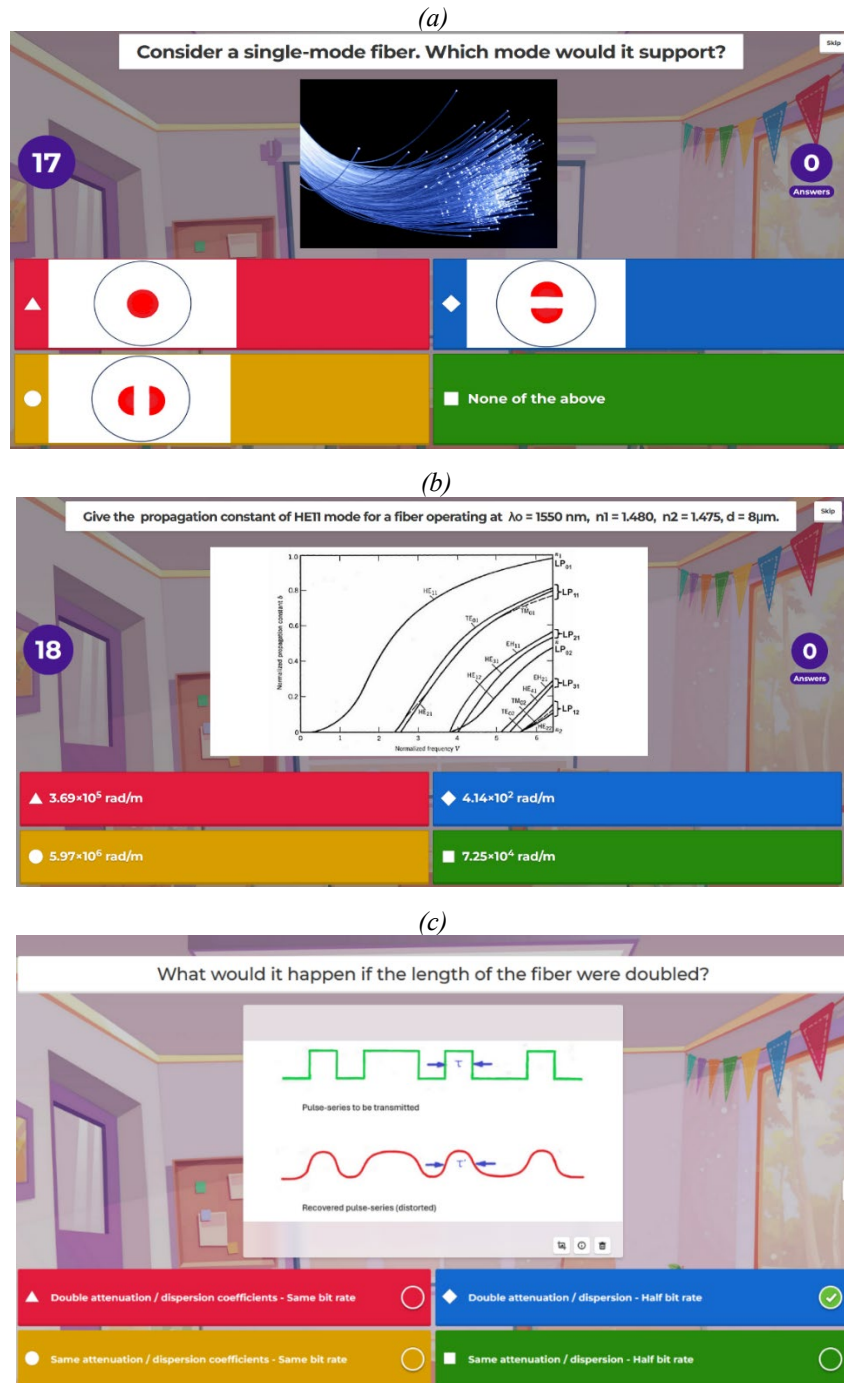


Table 2.
Indicative additional questions regarding electromagnetic propagation and signal transmission through fibers.

Question	Relevant figure
1. What would be the profile of the LP11 mode?	3a
2. Suppose that the picture depicts mode's profile, i.e. the distribution of the optical power over a cross-section of a single-mode fiber at an instant considered as the starting one ($t_0 = 0$). What comments can you make on the mode's profile at distances L such as $\beta L = \pi/4$, $\pi/2$ and π (where β is the mode's propagation constant)?	3a
3. What would be the mathematical expression of the electric field in a fiber with indices $n_1 = 1.480$ and $n_2 = 1.475$ and diameter $d = 12 \mu\text{m}$ operating at a wavelength $\lambda_0 = 1550 \text{ nm}$?	3a
4. Could there be an optical fiber with no propagating mode?	3b
5. Suppose we have an optical source operating at a wavelength $\lambda_0 = 1550 \text{ nm}$ and optical fibers with refractive indices $n_1 = 1.480$ and $n_2 = 1.475$ and diameters (d) equal to $8 \mu\text{m}$, $12 \mu\text{m}$, $16 \mu\text{m}$ and $20 \mu\text{m}$. Identify the propagating modes supported by each fiber.	3b
6. In what way, e.g. modes HE ₂₁ , TE ₀₁ and TM ₀₁ can be considered as the LP11 mode?	3b
7. Suppose that the figure depicts a signal with bit-rate $R = 2.5 \text{ Gb/s}$. What will happen if the bit-rate increases considerably (e.g. to $R' = 10 \text{ Gb/s}$)?	3c

5. DISCUSSION

5.1. Use of Concept Maps

There is no doubt that the use of concept maps assists educators in conveying a clearer picture of the presented notions and facilitates students' understanding by helping them create a well-structured overview of the topics of interest. Regarding telecommunications, concept maps can help students outline the subject of telecommunications (including its individual sub-areas and topics) and, at the same time, revise basic telecommunication notions and concepts. Moreover, the interrelation of the concept maps, as described in sub-section 4.1 and depicted in figure 4) can assist students in associating essential notions and facts with actual telecommunication services and applications which is compatible with students' participation and active learning.

Following the use of concept maps, and with the aim to evaluate their effect on students' comprehension, a short questionnaire was distributed to students that should be answered by means of a 5-grade Likert scale ("1" strongly disagree, "2" disagree, "3" neither disagree nor agree, "4" agree, "5" strongly agree). The questions and the answers' essential metrics are included in table 3.

Table 3.
Questions and answers regarding the use of concept maps to enhance students' comprehension of telecommunications (participation: 18 students). The Linkert scale was used (ranging from 1 to 5).

Question	Average (m)	Standard deviation (s)	Ratio m/s	Percentage with answers “4” or “5”
1. Concept maps helped me develop a better overview of the various aspects of telecommunications as a subject.	4.056	0.639	0.16	83.3%
2. Concept maps helped me realize critical parameters of the various types of telecommunication networks and services.	4.222	0.808	0.19	77.8%
3. Concept maps helped me in associating critical facts regarding telecommunication services and applications.	4.000	0.639	0.16	83.3%
4. I would use concept maps as an educator.	4.111	0.471	0.11	94.4%

Students' answers to questions 1, 2 and 3 (with averages 4.056, 4.222 and 4.000, respectively and a small m/s ratio) illustrate the fact that students generally agree that the use of concept maps had a positive effect on their comprehension of telecommunication issues.

The aim of question 4 was to evaluate the intention of the participating students to use concept maps as future educators. This question was included in the questionnaire given the fact that the department's graduates have the option to be employed as teachers of electrical and/or electronic engineering in technological high schools. It is encouraging that the majority of students would agree that the use of concept maps should be part of their teaching practice.

It is worthwhile noting that the percentage of students that gave a “4” or a “5” answer to the questions above was quite high (ranging from 77.8% to 94.4%).

Though the described use of the concept maps regards the overview of the telecommunication subject, concept maps could be also applied for the teaching of individual telecommunication topics, particularly those for which classification is necessary for students' comprehension. A notable example is the modulation and multiplexing techniques where correlation of individual concept maps would be helpful if not necessary. To enhance the effect of the associated teaching approach, concept maps could also refer to essential relevant information. For example, regarding modulation, concept maps might include information such as the signals involved, the spectral requirements, the modulation and demodulation arrangements etc. Active participation of students could be accomplished by asking them to create particular concept maps or develop alternative ones applying different classification criteria. Students' participation could be also assisted by interrelating individual concept maps in the manner shown in figure 4.

Through the clarification and structured classification of telecommunication notions, concept maps are also expected to help students in the literature survey related to specific telecommunication topics for which a usual complaint was that when they had to do such a survey, they often felt lost and confused. Finally, as future educators in technological high schools, they could also incorporate the use of concept maps in their teaching of electricity and electronics related topics, e.g. in the classification of electrical components or electronic amplifiers to name a few.

5.2. Use of the Kahoot Gaming Tool

Following the use of Kahoot, a short questionnaire was distributed to students that should be answered by means of a 5-grade Likert scale (as for the concept maps). The questions and the answers' essential metrics are included in table 4.

Table 4.

Questions and answers regarding the presentation of the use of the Kahoot gaming tool for the presentation of electromagnetic propagation and signal transmission through optical fibers (participation: 19 students). The Linkert scale was used (ranging from 1 to 5).

Question	Average (m)	Standard deviation (s)	Ratio m/s	Percentage with answers "4" or "5"
1. Kahoot gaming tool was easy to use.	3.632	0.895	0.25	68.4%
2. Visualization through the Kahoot gaming tool helped me comprehend EM propagation process through an optical fiber.	4.167	0.898	0.22	78.9%
3. Visualization through the Kahoot gaming tool helped me comprehend signal degradation phenomena such as dispersion.	4.105	0.658	0.16	84,2%
4. I would use Kahoot as an educator.	4.053	0.621	0.15	84.2%

The answers to question 1 ($m = 3.632$) show that regarding the usability of Kahoot, there is certainly room for improvement. This is compatible with the moderate percentage (68.4%) of students that gave a "4" or "5" answer to this question. A possible solution would be the students to be given some time to practice with Kahoot as a preparatory homework (prior to its use in the class).

The answers to questions 2 and 3 ($m = 4.167$ and 4.105 with a small m/s value) show that visualization through Kahoot prior to the mathematical analysis, did help the students comprehend the facts and issues of electromagnetic propagation and signal transmission through optical fibers.

The aim of question 4 was to evaluate the intention of the participating students to use Kahoot as future educators. This question was included given the fact that the department's graduates can be employed as teachers in technological high schools. It is encouraging that the majority of students agree or strongly agree with using Kahoot as future educators.

The above conclusions are compatible with the high percentage of students that gave a "4" or "5" answer to questions 2, 3 and 4 (78.9%, 84.2% and 84.2%).

Kahoot could be also used for the visualization of additional topics of Optical Communications, e.g. the operation of optical amplifiers and receivers or the wavelength division multiplexing technology, to name a few. Active participation of students could be enhanced by encouraging them to create their own Kahoot displays (probably with proper guidance and/or hints) in view of their possible employment as future school teachers. In the framework of more advanced applications, Kahoot could be also used for developing self-teaching educational material, e.g., for incoming international students.

6. POSSIBLE FUTURE DIRECTIONS

Regarding the use of concept maps, a future action could be the use of concept mapping software tools that would provide flexibility and greatly increase the didactic potential of concept maps. The use of software tools would enhance students' familiarity with concept maps and encourage the students to employ them in their potential capacity as educators in technological secondary schools. Such an action would also help students enhance the Technological Content Knowledge (TCK) part of the TPACK framework as well layer 4 ("analyze") of Bloom's taxonomy

As far as the Kahoot gaming tool is concerned, given the dynamic nature of electromagnetic waves (and waves in general) the use of video tools for the presentation of electromagnetic propagation and signal transmission through fibers, (which, however, would require more effort and more sophisticated equipment) could be also considered as an option.

7. CONCLUSIONS

All in all, the combined use of concept maps and Kahoot aimed at mitigating difficulties and complications regarding the teaching of telecommunication. The use of concept maps mainly referred to the telecommunication subject as a whole while Kahoot aimed at visualizing mathematically complicated topics (such as propagation and transmission through optical fibers) prior to their mathematical analysis and was also used for students' self-checking.

Regarding concept maps, the aim was to assist and possibly enhance students' comprehension of telecommunications in a rather overall manner. Apart from the conventional use of concept maps (to present a structured overview of the overall telecommunication subject), the article proposes an additional use which anticipates the correlation of individual map elements to illustrate essential features of specific telecommunication services and applications. Given that telecommunications is a vast subject with a large number of specific sub-areas and topics that may overlap with each other and/or intersect with other scientific fields, concept maps can assist students in defining and comprehending telecommunication concepts and processes and dissolving relevant misconceptions and missing points. This could be particularly helpful for graduates who would choose to be employed as teachers and educators in electronics and telecommunications related fields. The students' answers to the distributed questionnaire were a strong indication that the described use of concept maps had a positive effect on their comprehension of telecommunications. It was also encouraging that students appeared eager to use concept maps as possible future educators. A further employment of concept maps could anticipate their formation and elaboration with the use of computer tools.

Regarding the use of the Kahoot gaming tool, the aim was to facilitate a qualitative comprehension of mathematically complex telecommunication topics (such as the electromagnetic propagation and signal transmission through optical fibers) by means of the visualization of the relevant processes. The rationale was that visualization of such topics would facilitate students in approaching the subsequent complicated and time consuming mathematical analysis. Student feedback was encouraging and this could motivate further use of Kahoot. Given the dynamic nature of electromagnetic waves (and waves in general), the use of video presentations in combination with Kahoot (which, however, would require more effort and more sophisticated equipment) could be also considered as an option.

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KEY TERMS & DEFINITIONS

Digitization: The conversion of an analog signal to an equivalent digital one.

Modulation: The mixing of an information signal (representing voice, a still or moving image, data etc.) with an auxiliary signal (called “the carrier”) with the aim to enable and/or optimize the information signal's transmission. Depending on the type (analog or digital) of the information signal,

the form of the carrier (sinusoidal or pulse-train) and the particular parameter of the carrier to be affected (modulated) by the information signal (amplitude, frequency or phase of the sinusoidal carrier or amplitude, width or position of the pulses in the pulse-train carrier), there occur the various types of modulation shown in figure 2.

Multiplexing: The simultaneous transmission of multiple signals through the same medium. A typical example is radio and TV broadcasting where several stations broadcast within the same area and at the same time.

Dispersion: The widening of digital pulses during the transmission of a digital signal (e.g through an optical fiber) that may result in pulse overlapping and bit-rate limitations. Dispersion has various forms (e.g. intramodal dispersion, polarization-mode dispersion) and its effects are more obvious in long, high bit-rate links (length above 100 km and bit-rate above 1 Gb/s) that is why it is usually associated with fiber-optic links.

Dial-up services: The most notable example is conventional telephony. A characteristic feature of dial-up services is the so-called “circuit switching” which anticipates that the communicating parties are assigned a dedicated circuit for the whole duration of their communication (to enable uninterrupted transmission of information with negligible delay).

Data services: The most notable example is computer communication. A characteristic feature of data services is the so-called “packet switching” which anticipates that the overall information is divided into packets (each one including bits regarding the starting and the destination point) that can follow different routes before they reach their final destination.

Broadcasting services: They include radio and TV broadcasting.

Broadband network: The integrated digital network that is capable of accommodating in a unified manner all types of services (dial-up, data and broadcast) and gradually replaces the conventional dial-up, data and broadcasting networks. Fiber-to-the-home connections are part of the broadband network.

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Chapter # 26

ENHANCING MOTIVATION IN DENTISTRY EDUCATION THROUGH AN INTERDISCIPLINARY MULTIMEDIA PROJECT-BASED LEARNING APPROACH

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ABSTRACT

In recent years, fostering active student engagement and interdisciplinary learning in health sciences education has become increasingly important. This chapter presents an in-depth evaluation of the BioFilm project, an innovative Project-Based Learning initiative implemented with first-year Dentistry students at Universidad San Pablo-CEU, including both international and national students. Many dentistry students do not perceive the relevance of basic science subjects in their future profession, which can make learning process overwhelming. The BioFilm project was designed to bridge this gap by integrating Biology, Genetics, Biochemistry, and Physiology through collaborative didactic video creation. This approach promotes knowledge integration, encourages transferable skills development, and leverages Information and Communication Technologies (ICT) to enhance motivation. Drawing on the pilot project experience, this chapter offers a comprehensive analysis of its design, outcomes, and reflections from both students and faculty, highlighting key challenges and outlining recommendations for future implementation.

Keywords: project-based learning, interdisciplinary integration, student engagement, Information and Communication Technologies (ICT).

1. INTRODUCTION

Traditionally, first year curricula in health- related degrees, including dentistry have been structured in discrete subjects, often isolated from one another, limiting opportunities for integrated understanding and contextualization (Nehm, 2019). Furthermore, many dentistry students at the San Pablo CEU University struggle to see the immediate relevance of foundational subjects - such as Biology, Genetics and Biochemistry, and Physiology- to their future professional practice. This results in diminished motivation and fragmented learning experiences. Regretfully, this situation is common across Science, Technology, Engineering, and Mathematics (STEM) education, where educators must face the ongoing challenge of balancing knowledge acquisition with practical application (Freeman et al., 2014).

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University dropouts and delays in academic progress often reveal significant issues related to learning motivation, which are influenced by the perception of interpersonal relationships and the functioning of the educational environment (Peditzi & Spigno, 2012).

Student motivation is, therefore, a key factor in academic success, particularly in disciplines that require the integration of basic and applied knowledge. According to Self-Determination Theory (SDT) by Ryan and Deci (2000), motivation can be classified as intrinsic, when students engage out of interest and personal satisfaction, or extrinsic, when their actions are driven by external rewards. In the context of health sciences education, fostering intrinsic motivation is essential for achieving deep and lasting learning. However, many dentistry students perceive basic science subjects as disconnected from clinical practice, which can reduce their motivation and hinder knowledge integration.

Active learning methodologies such as Project-Based Learning (PBL) have gained attention due to their effectiveness in promoting deep learning, student autonomy, communication skills, and critical thinking (Pranjol et al., 2024). In this line of evidence, PBL fosters interdisciplinary understanding by encouraging students to apply knowledge across traditional subject boundaries within a real-world context. In this context, PBL engages students in a problem-solving scenario, promoting self-directed learning, the application of knowledge in practical settings, students' autonomy, capacity for communication and teamwork, and higher order thinking skills (Freeman et al., 2014). It also creates a dynamic learning environment where students actively participate, learn from diverse perspectives and knowledge areas, and build transferable skills (Pranjol et al., 2024).

The BioFilm project was specifically designed to promote interdisciplinary integration and active learning through the collaborative creation of didactic videos, with the aim of enhancing both intrinsic and extrinsic motivation among students (Ryan & Deci, 2000). This initiative seeks to demonstrate the relevance of basic sciences in clinical training, foster autonomy, creativity, and teamwork, and develop digital skills essential for the future professional practice of dentistry students.

2. BACKGROUND

The School of Medicine at CEU San Pablo University is characterized by its strong international orientation, offering Dentistry degree program in both Spanish and English. This results in a high proportion of international students from diverse geographical and cultural backgrounds, which enriches the educational environment. However, this diversity also presents challenges in fostering integration and in encouraging active participation from all students within the university setting. In fact, these factors, combined with the clinical orientation of the student cohort and the wide range of prior educational experiences, pose significant challenges when teaching basic sciences to first-year Dentistry students. Accordingly, not all students begin the course with the same foundational knowledge, which can hinder their ability to fully engage with both the subject matter and the educational project. Addressing these disparities requires the implementation of inclusive teaching strategies and personalized academic support.

This scenario was identified by the lecturers of Biology (1st semester), Genetics and Biochemistry, and Physiology (2nd semester). These three basic subjects are often perceived as heavily memorization-based, disconnected from the clinical aspects of dentistry and with new and complex concepts which may contribute to fragmented learning that decrease student interest and that intimidate and disengage students. Integrative approaches that promote interdisciplinary learning have therefore been promoted as key strategies to bridge this gap (Burgess et al., 2020).

Science, Technology, Engineering, and Mathematics (STEM) educators are often challenged and encouraged to refine their curricula to offer a balance between acquiring knowledge and its application to real-world contexts (Freeman et al., 2014). In dental education, several studies have highlighted the challenges related to student motivation and engagement in basic science subjects, such as Biology, Biochemistry, Physiology, and Genetics (McInerney & Fink, 2003; Taglieri et al., 2017). The BioFilm project, based on Project-Based Learning (PBL) strategies, was designed and tested in a pilot course during the academic year 2023/2024 in response to these educational needs, particularly focusing on increasing student engagement by integrating several foundational subjects across two semesters in the first year of the Dentistry program. Through collaborative creation of didactic videos, students synthesize and communicate complex scientific concepts, promoting not only knowledge acquisition but also transversal skills such as teamwork, project management, and digital literacy. Videos can also provide a student-centred resource that promotes peer learning and reflection. Furthermore, multimedia tools and video production into PBL contexts stimulates students' creativity and enhances the learning process by requiring students to organize and communicate complex information clearly and succinctly (Rasi-Heikkinen & Poikela, 2016). In fact, recent developments in higher education, accelerated by the COVID-19 pandemic, have underscored the imperative for effective integration of Information and Communication Technologies (ICT). The digital competence of students is increasingly recognized as a critical component of their employability and lifelong learning by the European Commission's Digital Education Action Plan (European Commission, 2020). Accordingly, the BioFilm project incorporates ICT tools strategically, tapping into students' familiarity with multimedia content to enhance motivation and learning outcomes. As this strategy not only promotes knowledge acquisition but also enhances communication, it would create a robust framework for effective and inclusive education given the multicultural origins of the CEU San Pablo University students. Thus, to ensure the integration of the acquired knowledge in the three previously mentioned subjects, first-year dentistry students were organized into work groups and selected a topic previously proposed by the lecturers. Throughout the academic year, they were encouraged to submit two videos, one per semester, in which they condense and integrate the knowledge from the different subjects in an engaging and informative manner. This pilot project has enabled the implementation of the suggestions for improvement informed by student feedback through final project surveys, as well as by the needs identified by the teaching staff throughout the project's development.

This context provides both the theoretical grounding and practical rationale for the design and implementation of the BioFilm project, highlighting its potential to strengthen interdisciplinary integration, enhance student motivation, and develop digital competencies within dental education. This chapter presents an expanded analysis of the BioFilm project, detailing its design, implementation, and outcomes, and reflects on lessons learned and future directions and aims to contribute to the broader discourse on innovative pedagogical approaches in health sciences education and to provide insights applicable to similar interdisciplinary educational initiatives (Panadero & Jönsson, 2013; Jönsson & Panadero, 2017; Tinoco et al., 2023).

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3. OBJECTIVES

- To develop an innovative strategy aimed at increasing student interest and motivation in basic science subjects (Biology, Genetics and Biochemistry, and Physiology) by demonstrating their relevance to clinical practice and future professional development.
- To promote interdisciplinary learning by integrating concepts acquired over two academic semesters, enabling students to achieve a holistic understanding of biological systems relevant to dentistry.
- To incorporate information and communication technologies (ICT) in the presentation of project-based learning (PBL) outcomes, specifically through the creation and dissemination of didactic videos, fostering skills in digital content creation which are increasingly vital in health education.
- To foster the development of key transversal competencies, including teamwork, critical thinking, and the ability to communicate complex concepts—skills essential for students' future professional practice.
- To assess the short-term and potential long-term educational impact of these innovations by analyzing student and faculty feedback, satisfaction rates, and specific learning outcomes, and by comparing results across academic years.
- To explore the applicability and transferability of the BioFilm model to other health science curricula and multicultural settings, contributing to the wider discourse on interdisciplinary and digitally mediated learning.

4. METHODS

4.1. Participants

In the 2023/24 academic year, a total of 150 students participated in the BioFilm project. The majority were female (72.47%) and aged between 18 and 20 years. Students were organized into self-selected working groups of 5 to 6 members, promoting peer interaction and collaboration from the outset.

The project was supervised by nine faculty members from two departments: Basic Medical Sciences (School of Medicine) and Chemistry and Biochemistry (School of Pharmacy). Each group was guided through the subjects of Biology (1st semester), Genetics and Biochemistry, and Physiology (2nd semester).

The BioFilm project was approved by the Ethics Committee of Universidad San Pablo-CEU under reference number 776/23/96.

4.2. Group Distribution and Topic Assignment

Students freely formed their groups during the first week of classes and chose a topic from a set of ten interdisciplinary topics carefully selected by the instructors. These topics were designed to integrate key concepts shared among Biology, Genetics and Biochemistry, and Physiology syllabi, including renal physiology, cholesterol synthesis or glucose metabolism among others. Assigning relevant topics early facilitated effective work planning and coordination. Each group was assigned a dedicated tutor, who provided ongoing support and monitored progress through scheduled sessions, helping maintain focus and ensuring conceptual integration (Figure 1). The assigned tutor was responsible for monitoring and supervising the project to ensure its proper development and to guide students whenever the topic or content deviated from the intended objectives.

4.3. Project Design and Implementation

The BioFilm project spanned two semesters and included two major deliverables designed to scaffold learning progressively (Figure 1):

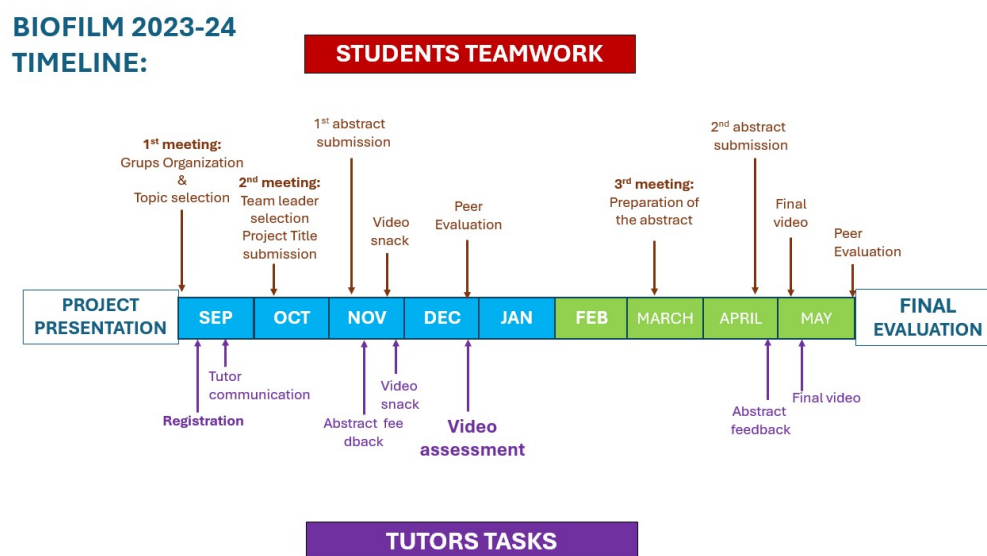
- **First Semester:** students worked on creating a short one-minute video or “snack”, focused on the biological perspective of the assigned topic.
- **Second Semester:** Students developed a final integrative video lasting up to three minutes, synthesizing interdisciplinary content from Genetics, Biochemistry, and Physiology alongside content from the previous semester’s Biology.

In both semesters, students submitted a preliminary script for their videos, evaluated their peer students and participated in tutoring sessions that provided guidance and support to enhance their work. This phased approach allowed students to build foundational understanding before developing more complex integrative outputs, promoting deeper learning and confidence.

4.4. Use of Technological Tools

The TEAMS platform was utilized as a virtual space to coordinate the project, enabling the submission of videos, script summaries, and tutoring sessions. Through this platform, professors continuously monitored and supervised students' progress. For video production, students had the autonomy to select video production tools best suited to their preferences and technical skills, encouraging creativity and diverse multimedia outputs.

Figure 1.
Project Biofilm timeline and key milestones of student and faculty tasks.



4.5. Evaluation and Assessment

The project assessment was multifaceted in order to capture various learning dimensions: First, the preliminary scripts for the videos were evaluated, contributing 5% to the final grade, encouraging preparation and organization. Second, a peer evaluation was conducted, which contributed 15% to the final grade with students assessing other groups’

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videos using standardized rubrics aligned with learning outcomes. Lastly, tutors and faculty applied a rubric to evaluate the final videos (Table 1), considering aspects such as originality, integration of the subjects' content, ability to synthesize information, teamwork, communication skills, and production quality (80%). Additionally, each student evaluated their own group members and performed a self-assessment, using rubric to foster reflection, personal accountability, and professional development. This project grade weighed 5% of the final grade in the three subjects.

The continuous monitoring of students during educational projects and the use of rubrics as an assessment tool are widely recognized practices in educational sciences due to their positive impact on achieving learning objectives (Panadero & Jönsson, 2013; Jönsson & Panadero, 2017; Cockett & Jackson, 2018, Hawe et al., 2021; Tinoco et al., 2023).

Table 1.
Rubrics for video evaluation.

Skill	Excellent (4)	Very Good (3)	Good (2)	Fair (1)
Creativity	Highly creative and original, ideas, innovative thinking.	Selectively and appropriately applies to others' ideas.	Incorporates others' ideas without critical evaluation.	Insufficient evidence to assess
Oral & writing communication	No grammatical, diction, or spelling errors.	Some grammatical, diction, or spelling errors.	Several grammatical, diction, or spelling errors.	Many errors.
Work planning, teamwork communication	Fully meets all requirements and even surpasses expectations	Successfully fulfills all specified requirements.	One criterion has not been fulfilled.	Several key requirements were not satisfactorily fulfilled
Concept integration Critical thinking	The content is relevant and appropriately incorporates information from the initial video, fulfills expectations	Updated content on the topic that appropriately integrates information from the first video	Good content, but poorly integrated.	Insufficiently developed content that does not fulfill the purpose of the assignment
Digital	The video and sound quality are excellent.	The video and sound quality are good.	Quality is not great, but sufficient.	Video does not have sufficient quality.

5. RESULTS

Final project surveys were designed to evaluate students' perceptions of the new learning approach and their level of satisfaction with the PBL methodology.

5.1. Quantitative Results

Of the 150 participants involved in the Biofilm teaching innovation project during the 2023 pilot course, a total of 65 students (43.33% of participants) completed the final survey. The demographic profile was female (74%) and between 18 and 20 years of age, and a 29.21% of the students were international students reflecting the multicultural nature of the Dentistry program.

Overall, the results showed students rated their satisfaction with the BioFilm project at an average of 7.6 out of 10, and 83.1% of respondents indicated they would recommend the project to their peers (Figure 2).

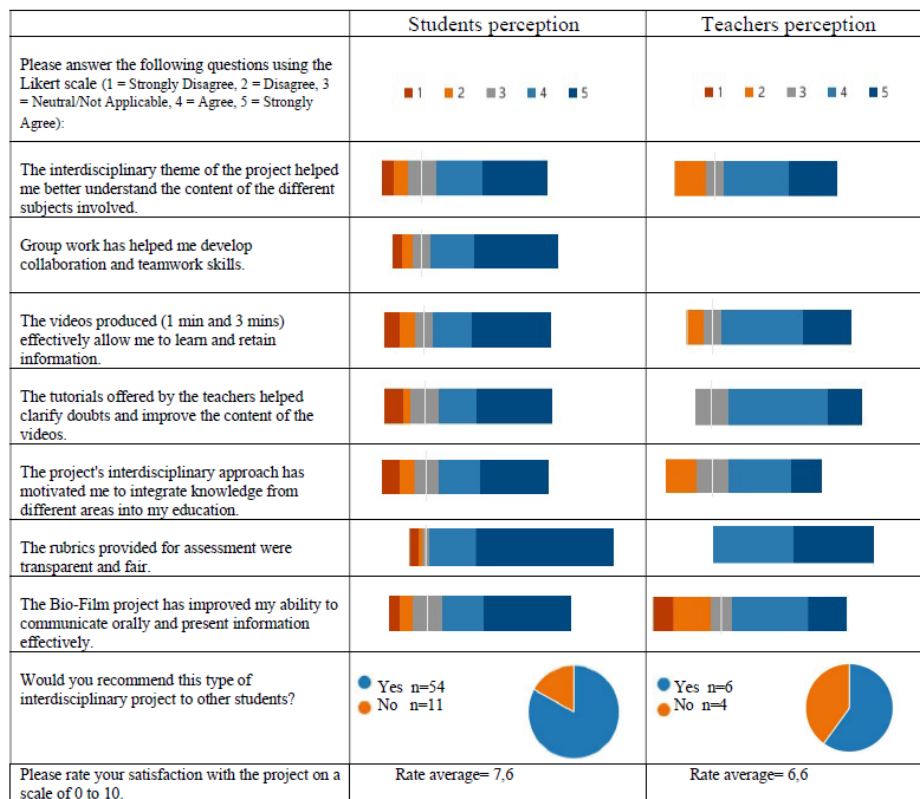
Most of the students surveyed agreed or strongly agreed that the interdisciplinary approach of the Biofilm project was effective in integrating the contents of the different subjects, that teamwork helped them to develop collaborative skills, and that videos helped them better understand the topic; the tutorials were useful in clarifying their doubts while completing the work. Moreover, the students also positively highlighted that the rubrics

provided for the evaluation were fair and clear and that the project improved their ability to communicate orally and present information from different subjects.

The BioFilm project aimed to balance intrinsic and extrinsic motivation. Autonomy in topic selection and creative video production nurtured intrinsic motivation, while rubrics provided structure and clarity, satisfying competence needs. However, as self-determination theory warns, excessive emphasis on grades can undermine intrinsic motivation (Ryan & Deci, 2020).

According to the survey, the perception of the educators regarding the usefulness of the project was only 6.6 out of 10, one point lower than the students' rating. However, educators were pleasantly surprised by the high quality of the video presentations submitted by students. These multimedia projects not only showcased technical proficiency but also demonstrated a deep integration of the knowledge acquired across the disciplines. The use of digital tools empowered students to creatively synthesize complex concepts, resulting in final products that exceeded expectations in both content and presentation. This experience highlights the potential of technology-enhanced PBL to foster meaningful learning and interdisciplinary collaboration. Moreover, the teachers unanimously agreed that the interdisciplinary focus and evaluation rubric were clear and effective. However, they noted challenges with tutorial follow-up, workload, and communication tools.

Figure 2.
Students' and teachers' perception in their learning and teaching experience during BioFilm project.



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5.2. Qualitative Feedback

Nevertheless, the implementation of PBL and multimedia projects faced several previously reported challenges, including initial student resistance, increased faculty workload, logistical complexities, and the necessity for adequate technological infrastructure and training (Shpeizer, 2019; Burgess et al., 2020). Students expressed positive sentiments including appreciation of the innovative learning method through video creation and the overall “perfect experience.” The constructive criticism focused on inconsistent tutorial sessions despite repeated contact attempts, lack of accountability for non-participating group members, perceptions of excessive workload with limited consequence for those not contributing.

Effective integration requires robust institutional support, structured pedagogical frameworks, clearly defined assessment rubrics, and continuous formative feedback mechanisms (Freeman et al., 2014). Given the multicultural and multilingual composition of the student body at Universidad San Pablo-CEU, the project also needed to address issues of linguistic and cultural diversity. Research suggests that when appropriately scaffolded, interdisciplinary PBL in multicultural contexts fosters stronger cohort identity and mutual understanding (Pranjol et al., 2024).

The educators suggested improvements centered around enhancing tutorial quality and regularity, better scheduling to meet academic goals, reconsidering the communication platform by adopting Blackboard instead of Teams, and the need for additional time allocated within the curriculum for such projects. Some faculty perceived that many first-year students struggled to grasp the project’s objectives, often treating it as a task to complete quickly rather than a learning opportunity. The use of assessment rubrics enabled educators to monitor the development of students’ competencies throughout the entire program, providing feedback and promoting continuous improvement in achieving learning outcomes. This systematic tracking, supported by well-designed rubrics, helps students understand the evaluation criteria and align their work with educational objectives (Panadero & Jönsson, 2013; Jönsson & Panadero, 2017; Tinoco et al., 2023).

5.3. Discussion

Starting a health sciences degree as dentistry often presents challenges for first-year students. Many of them enter with high expectations directly linked with clinical or applied subjects. However, their initial curriculum is composed by foundational courses as Biology, Genetics and Biochemistry and Physiology. This conflict between expectations and academic reality can lead to frustration, reduced motivation, and, in some cases, course withdrawal. Understanding and addressing these motivational gaps is essential to support student persistence and success.

In this context, the BioFilm project was purposefully designed to motivate dentistry students by fostering engagement and interdisciplinary learning while maintaining a balance between intrinsic and extrinsic motivational forces, as conceptualized by Self-Determination Theory (SDT). According to SDT, intrinsic motivation refers to engaging in activities for their inherent interest and enjoyment, whereas extrinsic motivation involves performing tasks to obtain external rewards or avoid sanctions (Ryan & Deci, 2000, 2020). Within this project, autonomy was embedded through student choice of topics and the creative process of producing educational videos, which nurtured intrinsic motivation by promoting ownership, creativity, and personal relevance. These elements align with SDT’s emphasis on supporting the basic psychological need for autonomy—a critical driver of deep learning and sustained engagement.

Overall, the BioFilm project was successfully implemented with first-year Dentistry students at Universidad San Pablo-CEU, was positively received and represents an innovative and multidisciplinary pedagogical initiative, grounded in Project-Based Learning (PBL) and the use of Information and Communication Technologies (ICTs). As PBL is not systematically integrated as into a teaching method in higher education, usually focused on a lectured format, it often relies on teachers its implementation and integration (Freeman et al., 2014, Shpeizer, 2019). Dentistry students commonly struggle to connect the theoretical content of Biology, Genetics, Biochemistry, and Physiology to their future clinical practice, resulting in low motivation and fragmented learning (Freeman et al., 2014; Nehm, 2019). BioFilm addresses these issues by fostering horizontal and transversal integration across disciplines through the creative production of didactic videos, promoting ownership of learning and collaboration. This chapter expands on the preliminary findings presented at the END 2025 conference (Arriazu Navarro et al., 2025), providing a more robust bibliographical framework and a comprehensive evaluation of the results.

The integration active methodologies such as Project-Based Learning and video creation appear to enhance both intrinsic and extrinsic motivation. Autonomy, creativity, and teamwork foster intrinsic motivation, while rubrics and grading serve as extrinsic incentives. Striking a balance between these types of motivation, as Ryan and Deci (2000) suggest, is essential for meaningful learning. The BioFilm project aimed to promote autonomy and self-assessment, while rubrics provides structure and clarity. However, some students reported challenges with workload and group coordination, highlighting the need for ongoing support and adaptation.

In this pilot test, first-year students were encouraged to freely form groups and choose their PBL topic (Burgess et al., 2020), where randomized group formation ensured a diverse background of students with different knowledge levels. Lecturers were responsible for designing and planning the different deliverables, assigning the tutors based on their area of knowledge for each topic, developing the rubrics, and selecting the format for the project presentation. Beyond the academic purpose, these kinds of projects supervised by a tutor can also influence the classroom dynamics. They promote a more collaborative atmosphere where students perceive lecturers as mentors rather than adversaries (Peditzi & Spigno, 2012). This change in perception could lead to increased engagement during the theoretical classes and the regular attendance, strengthening the overall learning experience and promoting a sense of belonging within the academic community. Thus, this activity created an ideal environment for first-year students to meet integration into university life. Video creation in educational settings has demonstrated significant benefits in enhancing student learning and integrating various subjects. Thus, students not only consolidate their knowledge through the process of scripting, filming, and editing but also develop critical thinking and technical skills. This hands-on approach fosters a deeper understanding of the material, encourages creativity, and provides a platform for collaboration among peers. Moreover, the skills acquired such as digital literacy, storytelling, and project management, are invaluable assets that can aid students in their future academic and professional endeavors (Rasi-Heikkinen & Poikela, 2016).

At the same time, the use of rubrics and the integration of project outcomes into course grading introduced extrinsic incentives. When implemented thoughtfully, such structures can satisfy the need for competence and promote internalization of extrinsic motivation toward more autonomous forms (identified and integrated regulation). Clear criteria and constructive feedback help students perceive evaluations as informational rather than controlling, thereby reinforcing their sense of efficacy and supporting self-regulated learning. In recognition of the students' effort in creating the Snack and final video throughout the semesters, their

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results were included in their final grade in each subject. This grade was based on both the professors' assessments and the students' evaluations through a peer review process, as well as the grades assigned among group members. While incorporating students' evaluations of their peers' PBLs into the overall grade can sometimes lack objectivity (such as potential conflicts arising from group work, lack of criteria for evaluation, and low engagement in reviewing videos), it can also encourage them to develop professional behavior and actively participate in the project. Moreover, peer evaluations provided valuable feedback on team cohesion and the perception of actual productivity (Burgess et al., 2020).

Consistent evidence supports that tracking students throughout a project, especially through the use of rubrics, is essential for achieving learning objectives (Panadero & Jönsson, 2013, Jönsson & Panadero, 2017; Cifrian et al., 2020; Hawe et al., 2021, Tinoco et al., 2023). Rubrics not only clarify success criteria but also promote self-regulation, self-assessment, and formative feedback-key elements in competency-based education. However, some studies warn that using rubric must be carefully designed to avoid rigidity and encourage creativity (Cockett & Jackson, 2018). However, SDT cautions that when assessments are experienced as controlling—focused narrowly on compliance or comparative performance—they can undermine intrinsic motivation and lead to controlled forms of regulation, often associated with anxiety and superficial engagement. To mitigate this risk, rubrics should be framed as tools for formative feedback, emphasizing progress and mastery rather than rigid compliance. Future iterations of the BioFilm project should strengthen autonomy-supportive practices by incorporating reflective self-assessment, peer feedback, and explicit rationales for evaluation criteria. These strategies transform grading from a source of external pressure into an opportunity for growth, maintaining the delicate balance between autonomy and structure that SDT identifies as essential for optimal motivation.

In general, the BioFilm project was positively received overall, particularly for its innovative integration of multimedia and interdisciplinary teamwork which students valued highly. The student agreement on the role of group work in developing collaboration skills highlights one of the core strengths of PBL strategies in health education (Taglieri et al., 2017). Moreover, the emphasis on the use of ICT aligns with the European Commission's Digital Education Action Plan, stressing digital competence as key to future employability and lifelong learning (European Commission, 2020). The integration of video production not only supports conceptual understanding but also enhances communication and digital literacy, critical skills for modern healthcare professionals.

The learning strategies adopted by the students not only involve their participation in a PBL making a commitment to their peers in the working group but also imply a change in dynamics with an increased workload that generates discontent and dropout among some of the students. In general, students tend to prefer passive learning over the active despite the benefits of the latter (Taglieri et al., 2017).

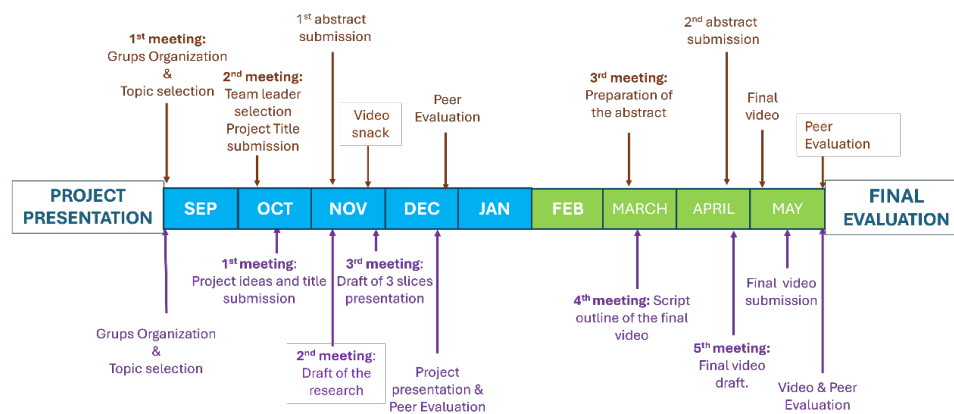
Nonetheless, the results of the satisfaction survey conducted at the end of the course reflected a high acceptance of the BioFilm project among the students, with 83.07% recommending it. There was a high proportion of "agree" and "strongly agree" responses to questions related to the improvement of integration, communication, and teamwork skills (Figure 2). This result aligns with those obtained by McNerley and Fink (2003), where after implementing Team-Based Learning (TBL), 81% of the surveyed students rated the project positively, stating that it not only benefited their learning but also the development of critical thinking, integration of concepts, and improved problem-solving efficiency. However, there were some limitations in the project that included modest survey response rates and potential positive bias in feedback. Challenges remain in standardizing peer evaluation and ensuring equitable team participation. Students' qualitative feedback also invites reflection on the

timing and structure of the project. Analyzing institutional policies and support systems is required for broader adoption of this type of project-based, interdisciplinary models, addressing workload balance and curricular integration challenges (Pranjol et al., 2024).

Faculty qualitative feedback also revealed increased workload, coordination difficulties, and inconsistent tutorial engagement. These reflect well-known barriers in implementing active methodologies and underscore the need for institutional support, structured mentoring, and manageable workload distributions (Shpeizer, 2019; Burgess et al., 2020).

Figure 3.
Improvements in BioFilm project timeline and key milestones.

BIOFILM 2023-24 TIMELINE



BIOFILM 2024-25 TIMELINE

6. FUTURE RESEARCH DIRECTIONS

Faculty members and student feedback highlighted important challenges that have guided subsequent improvements. The satisfaction surveys conducted during the 2023/24 academic year were carefully considered, and the suggestions made by students, along with the improvements identified by instructors, were implemented in the 2024/25 academic year.

To streamline communication, submissions, tutorials, and announcements with students, it was decided to adopt Blackboard as the single platform instead of Teams during the 2024/2025 academic year. Since this is the system students regularly use for their courses, this change will minimize issues related to unfamiliarity with the tool, saving time and reducing frustration.

To ensure more personalized and detailed student follow-up, mandatory academic tutoring sessions were increased throughout both semesters (Figure 3). Furthermore, to enhance the structure and accountability of student-tutor interactions, students of 2024-2025 are now required to produce a written summary (meeting minutes) after each tutorial session. These summaries serve as a reflective tool and a record of progress, ensuring continuity and clarity throughout the development of the project.

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Additionally, the video-snack activity used in the first semester was replaced by a three-minute oral presentation introducing the topic to be discussed in the final video. Also, given the 1st year experience, a special emphasis was placed on the creation of outreach videos using new technologies, moving away from traditional PowerPoint presentations.

The iterative adaptations introduced—mandatory tutorials, platform migration to Blackboard, refined deliverable formats—respond directly to these findings and are expected to enhance student engagement, clarify expectations, and optimize workload distribution to improve outcomes in future course editions.

Longitudinal studies and broader implementation assessments will be necessary to measure sustained impacts on academic success and professional skill development.

7. CONCLUSIONS

The BioFilm project demonstrates that combining Project-Based Learning (PBL) with creative video production is an effective strategy to enhance motivation and engagement in health sciences education. By promoting autonomy through topic selection and collaborative work, the initiative fostered intrinsic motivation, while rubrics and grading served as extrinsic incentives, reinforcing competence when applied as informational tools.

Furthermore, the project improved conceptual understanding, interdisciplinary integration, and the development of key skills such as digital literacy, teamwork, and project management. Survey results confirmed high levels of student satisfaction and perceived relevance. However, challenges related to workload and coordination underscore the need for ongoing support.

Future iterations should strengthen autonomy-supportive practices—such as formative feedback, self-assessment, and peer evaluation—while ensuring that assessments remain growth-oriented rather than controlling. Ultimately, the BioFilm project illustrates how technology-enhanced PBL can drive motivation, skill development, and academic success.

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Chapter # 27

EMBODIED LEARNING THROUGH APPROACHING WORKS OF ART IN THE EDUCATION OF FUTURE KINDERGARTEN TEACHERS

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ABSTRACT

This paper aims to explore embodied learning through approaching works of art in the context of educating future kindergarten teachers and to contribute to the application of contemporary theory of embodied cognition in Pedagogical Departments. The study highlights the pre-existing perceptions of future kindergarten teachers regarding the use of embodied learning through approaching works of art in the classroom or in a museum environment and proposes, based on students' concerns and needs, a workshop grounded in this approach. A two-phase mixed research study was conducted. In the first phase, 53 undergraduate students completed an initial questionnaire, followed by analysis of their responses. Based on the findings, a four-phase workshop was designed and implemented, simulating experiential embodied learning practices for the school classroom. In the second phase, 23 students from the initial sample participated in the workshop and completed a second questionnaire. Data were analyzed using descriptive statistics and thematic analysis. Findings from the first phase indicate that future kindergarten teachers associate artistic, physical, and cultural experiences with key aspects of comprehensive preschool development. Reflections from the second phase revealed deeper emotional engagement's motor activation, empathy, creativity, and participation in learning, highlighting the workshop's potential in teacher education.

Keywords: embodied cognition, experiential learning, higher education, museum pedagogy, psychomotor education.

1. INTRODUCTION

Despite the insistence on traditional mind-centered teaching methods, which separate the body from the mind and have the learner sitting in a chair in a classroom, listening and writing, it is now increasingly recognized that movement and the experiences associated with it play an important role in the learning process (Macrine & Fugate, 2022; Wilson & Foglia, 2015). From early childhood, movement and physical experience play a crucial role in the development of cognition and understanding (Pourkos, 2015; Kosmas & Zaphiris, 2018; Barsalou, 2008). However, teacher education programs often focus on theoretical knowledge and provide limited guidance on how movement or museum visits can be integrated in the teaching practice (Koufou, 2025; Wu, 2024; Hilde & Ørbæk, 2024; Dimitriadi & Malafantis, 2022). This creates a disconnect between the teaching practices and the sensory, embodied experiences that characterize the learning process. In recent years, at the Department of Preschool Education at the University of Crete, we have begun to address this disconnect by incorporating embodied learning activities (such as guided sensory-motor games, games involving emotional engagement, body expression, and improvisation) into the curriculum, often using works of art as a starting point (Trouli, & Trouli, 2025).

2. BACKGROUND

2.1. Embodied Cognition and Embodied Learning

The theory of embodied cognition, formulated in the 1990s, argues that the state in which our body interacts with our cognitive processes (Barsalou, 2008; Wilson & Golonka, 2013; Wilson & Foglia, 2015). It is rooted in the phenomenological theory of Martin Heidegger and Maurice Merleau-Ponty (1962); according to this theory, the physiology of the human body and the environmental experiences an individual has with their body determine the way they think (Vasilaki, 2023; Kai-Kee, Latina & Sadoyan, 2020). The body and its sensory-motor capabilities serve as a point of orientation in the environment and, as such, a fundamental landmark for learning, developmental, and cognitive experiences (Pourkos, 2015). Knowledge does not dwell in abstract and symbolic representations but is built through sensory-motor interactions with the environment, where thought, language, and cognitive processes are intrinsically connected to the body. Embodied learning is not simply an experiential process, but the basis of cognitive activity driven by the body (Kallinou, 2021). In embodied learning, movement must be intertwined with the learning content to strengthen meaningfulness.

By changing the traditional ways of teaching and learning, embodied learning uses the body, the senses, the mind and the environment (Shapiro & Stolz, 2019; Paniagua & Istance, 2018). As an educational method, embodied learning is growing in popularity in the modern education system. It is described as a kinesthetic teaching method, predominantly involving the reproduction of movements and gestures, as well as emotional engagement. The student takes on an active role, where elements of their personality, sensations, thoughts, and emotions become the focus. The body no longer serves as a sterile "depository" of knowledge but is transformed into the primary teaching tool, both inside and outside the classroom (Barsalou, 2010). By combining information with a kinesthetic stimulus that excites the student's interest, the brain is thus stimulated, converting short-term memory into long-term memory and ultimately cementing that experience as knowledge (Kallinou, 2021; Smyrniou, Sotiriou, Georgakopoulou & Papadopoulou, 2016). Theater and dance are the main ways to do this (Vasilaki, 2023; Papadopoulos & Mamali, 2021).

Especially for children, motor and perceptual experiences form the basis of education (Quarello, 2024; Watson, & Delaney, 2024). Activities and educational environments that engage movement and encourage students to move in specific ways enhance the learning process. In addition, embodied educational interventions and interactions make knowledge accessible to all students, providing them with more opportunities for active participation (Foglia & Wilson, 2013; Kosmas & Zaphiris, 2018).

Research shows that embodied approaches help students understand complex or abstract concepts through physical and emotional experiences (Papadopoulos & Mamali, 2021; Smyrniou et al., 2016). For example, theater and movement have been successfully used in education to address sensitive issues such as the refugee experience (Trouli, 2023). This is linked to international pedagogical trends that call for the development of innovative teaching approaches beyond oral and linguistic methods, through the integration of experiential and creative activities (Paniagua & Istance, 2018). Moreover, research in arts education shows that physical engagement with art can deepen participation and understanding (Hubard, 2007; Kukkonen, 2022). Even within adult education, embodied experiences are recognized as a powerful learning tool (Freiler, 2008). Overall, these findings highlight embodied learning's potential to promote engagement, empathy, and deeper understanding; elements that are particularly important in the education of teachers.

2.2. Embodied Learning through Works of Art in Museums or in the Classroom

Museums, as non-typical learning environments, are excellent settings for embodied learning to flourish. They offer multimodal, comprehensive experiences that engage both mind and body (Wanttie, 2024; Kai-Kee et al., 2020). Contemporary posthumanist approaches in education argue that learning is distributed across bodies, objects, and environments rather than confined to the individuals' minds. In the context of museums, this implies that exhibits and works of art can be considered to be "active participants" in the learning process rather than merely passive objects (Hackett, Holmes, & Macrae, 2020). In recent years, a "body-centered pedagogy" has emerged in museums, encouraging visitors to engage with exhibits using their bodies and all their senses, rather than being limited to sight and hearing (Christofalou, 2021). This physical and sensory engagement can offer more personal and meaningful interpretations of works of art.

However, transporting young children from school to the museum is often not easy. Thanks to the development of emerging technologies, and the materials provided by museums, works of art can be displayed and used in the classroom (Kalesopoulou & Trouli, 2025). In fact, teachers can employ the Gallery Walk, a technique that engages learners physically and encourages active participation in the learning process (McCafferty & Beaudry, 2017).

A research gap has been identified in the field of teacher education between the teaching/learning process and the sensory and embodied experiences (Hilde & Ørbæk, 2024). A lack of courses on the utilization of art and museum experiences through embodied learning, both in the classroom and in the museum, has also been identified by both future and current educators (Koufou, 2025; Sotiropoulou-Zormpala, Trouli & Linardakis, 2010; Sotiropoulou-Zormpala, Trouli & Linardakis, 2015; Dimitriadi & Malafantis, 2022; Oikonomidis & Trouli, 2022; Trouli, 2023).

2.3. Purpose and Research Questions

This study investigated the perceptions of students in the Department of Preschool Education at the University of Crete concerning the use of embodied learning when approaching works of art in the classroom or in a museum environment. More specifically, it investigates how future kindergarten teachers perceive the use of embodied learning through the approach to works of art. A workshop was subsequently designed, based on the perceptions and needs of the participants, applying this approach in practice, and the participants' feedback was reviewed. The research questions prior to the implementation of the workshop focus on: (a) investigating the participants' general perceptions and experiences of museums, (b) researching their theoretical perceptions and expectations of embodied learning, (c) recording their perceptions on the role that movement plays in learning and development, and (d) exploring the associations between the participants' perceptions of museums and the contributions of embodied learning to the comprehensive development of children. In addition, following the implementation of the workshop, the research questions focused on (a) evaluating the pedagogical experience of the workshop, (b) the difficulties and obstacles in implementing embodied learning, and (c) perceptions of embodied learning and the experiences associated with it.

3. METHODOLOGY

3.1. Participants

The research sample in the first phase of the study consisted of 53 undergraduate students ($n = 53$), of whom 51 were women and 2 were men, with the main age distribution being 20-22 years old. This ratio reflects the actual demographic composition of students in Preschool Education Departments in Greece. All participants were in their final two years (3rd and 4th year) of their studies at the Department of Preschool Education at the University of Crete during the academic year 2024-2025. The sample was selected through convenience sampling, as the participants attended the Department's Psychomotor and Museum Education seminars during the spring semester of that year. The students who took part in the research had an academic background in arts education, including courses focused on preschool age, and specifically courses in preschool pedagogy, aesthetic education, psychomotor education, music and rhythmic education, museum education, theater education and visual arts.

In the second phase of the study, from the initial sample of 53 students, a convenience sample consisting of 23 female students ($n = 23$) was selected from an existing seminar class. This sample's sub-group was designated as the group for the workshop.

3.2. Research Design

This study followed a mixed two-phase research design, combining, on the one hand, a survey of the students' perceptions of their previous museum experience and embodied learning, and, on the other hand, the design, implementation, and evaluation, by the sample sub-group, of a workshop based on embodied learning. The initial digital questionnaire was completed by the participants in the first phase of the research during February 2025, followed by the design and implementation of the workshop with the research sample in early March 2025, and the completion of the final digital questionnaire by the participants. The workshop was implemented as part of a seminar course in collaboration with the Department's psychomotor and museum education instructors and lasted two hours. The research was approved by the Ethics Committee of the Department of Preschool Education (641/19.06.2024).

3.3. Research Tools

The data were collected through two online digital questionnaires (Google Forms) designed for the purposes of the study. The initial digital questionnaire consisted of 19 closed-ended questions on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) and 8 open-ended questions; it was completed by all participants in the first phase of the study. Specifically, the questions in the first digital questionnaire were grouped into three sections: 1) general perceptions and experiences about museums, 2) theoretical perceptions and expectations about embodied learning, and 3) perceptions about the role of movement in learning and development. The second digital questionnaire consisted of 11 closed-ended questions on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) and 10 open-ended questions; it was completed by the sample sub-group that participated in the workshop. Specifically, the questions in the second digital questionnaire were grouped into three sections: 1) evaluation of the pedagogical experience of the workshop, 2) difficulties and obstacles in implementing embodied learning, and 3) perceptions of embodied learning and the experiences associated with it.

The responses to the open-ended questions in both digital questionnaires were subjected to thematic content analysis (Tsiolis, 2018), where repetitive ideas were systematically encoded, classified into categories, and transformed into dichotomous variables (yes = 1, no = 0). Next, the absolute frequency (N) and relative percentage (%) of students who reported each category were determined to record the distribution of topics/categories across the sample. The answers to the closed-ended questions were analyzed quantitatively by calculating descriptive statistics (mean and standard deviation) for each topic/category (Chalikias, Lalou, & Manolesou, 2015).

Both digital questionnaires were checked for internal consistency of their questions (Cronbach's Alpha reliability test). Internal consistency was assessed for each individual section of each digital questionnaire.

On the digital questionnaire for the first phase of the study, which was completed by 53 students, it was found that, in the first section, "general perceptions and experiences about museums", the reliability of the 15 items in the section was considered to be good ($\alpha = 0.783$, $N = 53$). In the second section, "theoretical perceptions and expectations about embodied learning", the reliability of the 36 items was considered to be high ($\alpha = 0.964$, $N = 52$), and finally, the third section, "perceptions about the role of movement in learning and development", presented good internal consistency in the 8 items that were completed ($\alpha = 0.833$, $N = 53$). These values in all three sections of the digital questionnaire indicate that the questions in the section reliably measure the same contextual field (Tavakol & Dennick, 2011).

Similarly, for the digital questionnaire completed by the 23 students after the workshop, it was found that, in the first section, "evaluation of the pedagogical experience of the workshop", the reliability of the 16 items in the section was good ($\alpha = 0.883$, $N = 23$). In the second section, "difficulties and obstacles in implementing embodied learning", the reliability of the 16 items was adequate ($\alpha = 0.791$, $N = 23$). Finally, the third section, "perceptions of embodied learning and the experiences associated with it", exhibited high internal consistency in the 18 items that were completed ($\alpha = 0.912$, $N = 23$). Overall, the reliability values across all sections of both digital questionnaires indicate that the questions reliably measure the same contextual field (Tavakol & Dennick, 2011).

4. RESULTS OF THE FIRST-PHASE DIGITAL QUESTIONNAIRE

4.1. General Perceptions and Experiences about Museums

Regarding the first research question about the perceptions of the 53 students and their experiences of the museum, each student was requested to write down three words that came to mind when they heard the word museum, three things they liked about museums, and three things they thought were missing from museums. They were also asked to answer how visiting a museum or using works of art in the classroom would help preschool-aged children.

In their attempt to capture the notion of "museum," the students used the words statues ($N = 21$, 39.6%), history ($N = 16$, 30.2%), art ($N = 16$, 30.2%), exhibits ($N = 15$, 28.3%), paintings ($N = 14$, 26.4%), and culture ($N = 12$, 22.6%). Students perceive museums as places of: art and exhibits (objects, sculptures, paintings, jewelry, frescos, pottery, tombs, photographs) ($N = 36$, 68%), information, exploration, discovery, and learning (activities, educational actions, guided tours, visual material, etc.) ($N = 19$, 36%). According to the students, significant deficiencies in museums are observed in the following areas: museum education (museum educational activities, experiential activities, interactivity, hands-on interaction with the exhibits, games, entertainment, audio tours) ($N = 28$, 52.8%), exhibitions and collections (lack of technology, methods of presenting exhibits, lack of music) ($N = 17$,

32.1%), organizational issues (space and visitor management, more staff, better information and promotion, spaces for children) (N = 13, 24.5%), and on issues of access (physical access and access for people with disabilities, cognitive access, free admission, cheaper tickets, funding) (N = 12, 22.6%).

4.2. Theoretical Perceptions and Expectations for Embodied Learning through Approaching Works of Art

Regarding the theoretical perceptions and expectations of the 53 study participants on embodied learning, that utilizing works of art in the classroom or visiting a museum helps enrich the children's stimuli and experiences (M = 4.5, SD = 0.7), helps in the acquisition of knowledge (M = 4.5, SD = 0.6), supports their aesthetic development (M = 4.4, SD = 0.8), the development of their cultural awareness (M = 4.5, SD = 0.7), the development of their empathy (M = 4.3, SD = 0.9), their social development (M = 4.2, SD = 0.8), their linguistic development (M = 4.1, SD = 0.8), the development of their physical expression (M = 4.0, SD = 1.1), the development of their civic awareness (M = 4.0, SD = 0.9), the development of their environmental awareness (M = 4.0, SD = 1.0), and, finally, the development of their nonverbal expression (M = 4.0, SD = 1.3). Subsequently, the application of embodied learning through approaching works of art in the kindergarten classroom finds the students in our sample to be in agreement (M = 4.4, SD = 0.75). In particular, they believe that embodied learning can contribute to a better understanding and consolidation of knowledge (N = 17, 37.8%). When asked about the contribution of movement to the sensory experience of exhibits and works of art, students seem to "agree" (M = 4.2, SD = 0.9). In fact, they believe that movement contributes to a better understanding and consolidation of knowledge through experience, body, and senses (N = 24, 45%). Students also "agree" that, through movement and awareness of the exhibits, we can address difficult concepts, such as the issue of refugees (M = 4.0, SD = 1.14), and point out that sensory and movement-based engagement with exhibits can strongly enhance empathy and deepen understanding of complex or difficult experiences/situations (N = 21, 40%); they believe that movement is a good way to approach difficult topics (N = 13, 28.9%).

4.3. Perceptions on the Role of Movement in Learning and Development

The perception that works of art can serve as motivation for children's motor activation is "agreed" upon by the 53 students (M = 4.33, SD = 0.79); 35.8% of them (N = 19) believe that works of art are a source of inspiration for body representation, but they point out that the application of appropriate educational approaches and works of art is required (N = 13, 25%). Lastly, the students in the sample "agree" that movement and the experiences associated with it play an important role in the processes of: emotional expression (M = 4.40, SD = 1.0), physical and motor development (M = 4.41, SD = 1.06), social development (M = 4.26, SD = 1.04), education and learning (M = 4.24, SD = 1.01).

4.4. Correlation Analysis

In order to gather feedback from participants on the design of the workshop on embodied learning through approaching works of art, we analyzed the correlations between the answers provided by the 53 participants in the initial digital questionnaire.

The analysis showed that the greater the degree to which future teachers believe that children acquire knowledge through works of art in classrooms or cultural spaces, the more likely they are to understand that: the children's stimuli and experiences are enriched (strong correlation, $r = 0.708$, $p < 0.001$), their empathy develops ($r = 0.621$, $p < 0.001$), their

linguistic development is enhanced ($r = 0.619$, $p < 0.001$), their cultural and civic awareness is strengthened ($r = 0.602$ and $r = 0.531$, $p < 0.001$), their aesthetic development is cultivated ($r = 0.440$, $p = 0.001$), and their physical expression is developed ($r = 0.431$, $p = 0.001$). Furthermore, the more the students in the sample perceive works of art as a motivation for children's motor activation, the more they realize that: the children's cultural awareness is cultivated ($r = 0.567$, $p < 0.001$), their environmental and civic development is strengthened ($r = 0.560$, $p < 0.001$ and $r = 0.419$, $p < 0.05$ respectively), their stimuli and experiences are enriched ($r = 0.481$, $p < 0.001$), their linguistic development is strengthened ($r = 0.478$, $p < 0.001$), their social development is enhanced ($r = 0.476$, $p < 0.001$), and their aesthetic development is cultivated ($r = 0.418$, $p < 0.05$).

The more future teachers believe that using works of art in the classroom or visiting cultural sites develops the children's physical expression, the more they realize that: their empathy is cultivated (strong correlation, $r = 0.713$, $p < 0.001$), their aesthetic and linguistic development is enhanced (strong correlation, $r = 0.711$, and $r = 0.705$, $p < 0.001$), their stimuli and experiences are enriched ($r = 0.600$, $p < 0.001$), and their cultural awareness is strengthened ($r = 0.602$, $p < 0.001$). Furthermore, the more they consider that these experiences develop the children's "empathy," the more they believe that: the children's stimuli and experiences are enriched (strong correlation, $r = 0.709$, $p < 0.001$), their language development is significantly enhanced (strong correlation, $r = 0.759$, $p < 0.001$), their cultural awareness is cultivated to a very high degree (strong correlation, $r = 0.767$, $p < 0.001$), their physical expression and aesthetic development are enhanced (strong correlation, $r = 0.713$, and $r = 0.681$, $p < 0.001$), and their environmental awareness is strengthened ($r = 0.613$, $p < 0.001$).

The more future teachers believe that embodied learning should be applied when approaching works of art in the classroom or in museums, the more they realize that: movement helps children become aware of the exhibits and works of art ($r = 0.459$, $p < 0.001$), through the movement and the exhibits they can approach complex and difficult concepts such as the issue of refugees ($r = 0.453$, $p < 0.01$). Furthermore, the more they recognize the role of movement and experiences in education and learning processes, the more they believe that: children's knowledge acquisition is enhanced ($r = 0.454$, $p < 0.001$), their stimuli and experiences are enriched ($r = 0.448$, $p < 0.001$), and their civic, cultural, and environmental awareness is cultivated ($r = 0.487$, $p < 0.001$, $r = 0.483$, $p < 0.001$ and $r = 0.410$, $p < 0.05$).

Finally, the analysis showed that the more future teachers recognize the importance of movement and experiences for the children's social development, the more they believe that: the children's stimuli and experiences are enriched ($r = 0.450$, $p = 0.001$) and their cultural awareness is strengthened ($r = 0.483$, $p < 0.001$). Similarly, the more they appreciate the role of movement and lived experiences in expressing emotions, the more they realize that: the children enrich their stimuli and experiences ($r = 0.409$, $p < 0.05$) and cultivate their cultural awareness ($r = 0.491$, $p < 0.001$).

The findings indicate that future kindergarten teachers believe that artistic, physical, and cultural experiences are closely linked to central aspects of comprehensive development during the preschool years. Educationally, these findings support the view that embodied, movement-based learning in preschool education is a powerful instrument for the comprehensive development of children (somatic, linguistic, social, aesthetic, cultural, environmental, and civic).

The participants' perceptions also highlight that body expression and empathy are key to how art and culture experiences support language, aesthetic, cultural, and environmental development, and that movement and the embodied perceptual awareness of works of art are an essential means not only for understanding educational material, but also for approaching complex social issues and cultivating civic, cultural, and environmental awareness. These findings also reveal that movement and the experiences that accompany it not only serve as a means of somatic activation but are also closely linked to the enrichment of experiences, cultural awareness, social development, the expression of emotions, and the cultivation of empathy.

Based on these findings, it is pedagogically reasonable to design artwork-engagement activities that include the children's movement, gestures, roles, and body representations, rather than just looking at a painting or discussing it. Without generalizing the results indiscriminately, the data support the gradual and systematic integration of forms of dramatic play, movement and body expression activities, and improvisation activities centered on works of art into the weekly kindergarten schedule, provided that they are further explored in future studies.

5. WORKSHOP DESIGN AND IMPLEMENTATION

Based on the above findings, an embodied learning workshop was designed and implemented with the aim of gathering feedback for the future design of similar workshops. We chose the issue of refugees as a case study because it is a timeless and, at the same time, a very relevant topic. Throughout history, countless people have been forced to leave their homes, persecuted by oppressive regimes, ethnic or religious hatred, and the horrors of war (Loescher, 2021). At the same time, kindergartens across Europe and Greece are welcoming refugee children, and it is important to have such workshops for the professional development of future kindergarten teachers with the aim of raising awareness of the refugee issue among the general population. Furthermore, the choice of refugee issue as a theme reflects the findings of the first phase of the research, where respondents highlighted the role of empathy. A memorial public artwork in Rethymno (an expressive sculpture honoring the refugees of the 1922 Asia Minor Catastrophe) served as the main inspiration and visual reference point for the workshop.

Based on this theme, we identified four sub-themes of the refugee experience, each associated with a color: (1) Uprooting - New Roots / Journey - Boat (blue), (2) Refuge - Hospitality - Hope (white), (3) Homeland - New Homeland - Suitcase (yellow), and (4) Obstacles - Crossings - Borders (green). We selected five to six photographs of works of art or objects for each sub-theme and displayed them in the workshop space structured according to a gallery-based presentation model. The workshop was based on museum education methods, including narrative storytelling, guided questioning (Socratic method), discovery learning, and experiential-creative activities (Nikonanou, 2015).

In terms of practical implementation, the space was decorated with various materials (e.g., fabrics, simple musical instruments, cardboard boxes) and music tracks and narrative excerpts were selected to facilitate deeper immersion in the theme. In addition, excerpts from the oral testimonial accounts of a child refugee from 1922 (Fryganakis, 2022) were used to add authentic voices to the experience.

The following stages present the progression of the workshop activities.

5.1. Stage 1: Music Immersion and Body Activation

We began by inviting the group to close their eyes and listen to a captivating soundscape we named "Music of Destruction". The selected music (Saleas & Vangelis, 1987) created an atmosphere of tension and loss, evoking the feelings of turmoil associated with violent uprooting. During this "embodied listening" phase, participants were encouraged to let the music guide their emotions and physical reactions.

When the participants opened their eyes, we suggested a sequence of movements to physically express elements of the refugee experience: for example, reacting violently to the sound of a war siren, walking with heavy steps full of anxiety, reaching out as if searching for something, taking careful steps backward, walking sideways through an imaginary narrow passage, curling up in fear, walking on tiptoes, hiding, protecting their heads, running or even swimming to escape. We accompanied the movements with sounds from a tambourine to indicate the transitions.

About halfway through this stage, we read aloud a narrative excerpt from the oral testimony: "The ship 'Patris, unforgettable, brought us packed like sardines and distributed us throughout Crete. Our human cargo was unloaded onto black boats out at sea and later dumped at the Venetian port of Rethymno. A pile of rags, body and soul!..." (Fryganakis, 2022).

As the music shifted to another musical track, a melancholic composition by Reboutsika (2000) and then to an emotional theme by Karaindrou (2010), the participants began to move freely around space. They observed their internal, physical reactions (heart beating fast, shivers, muscle tension, emotions surfacing) and connected these sensations with the central themes that we were exploring: xenophobia, loss, and hope.

We continued with an interactive group activity to symbolize the connection but also the obstacles/difficulties created by displacement and resettlement. We gently touched some of the participants, asking them to sit on the floor, defining them as "locals," while the rest remained standing as "newcomers" or "refugees". Then, one participant was handed a ball of yarn, which was passed from one person to another, with everyone saying their name. As the yarn was unraveled, it created a web connecting all the participants.

In the reverse process of wrapping the ball of yarn, each participant was asked to name (metaphorically, as a "refugee" or as a "local") an obstacle/difficulty they had faced when arriving in a new place or welcoming refugees to their place. Participants reported difficulties such as language barriers, finding housing, financial concerns, job hunting, fear of the unknown or experiences of prejudice, and concerns about their children. With each twist of the yarn and the name of the obstacle, the participants physically represented the difficulties they had experienced, but also the bonds that had begun to form in the group between "newcomers" and "locals". After everyone had spoken and the ball of yarn had been wound up, the group agreed that the web formed by the yarn symbolized both the difficulties and the bonds of solidarity between people.

5.2. Stage 2: Exploring Concepts

In the second stage, participants were asked to walk around the space and observe the gallery of images representing the four sub-themes (blue, white, yellow, green). At that point, we discreetly placed a colored sticker on each participant's hand, assigning them to one of the four color-coded groups, without initially revealing what each color represented. They then had to find and gather with other people who had the same color, helping each other discover which sub-theme their color corresponded to.

Once the four groups were formed (one for each sub-theme), they were given time to work on the works of art corresponding to each group's color. We distributed a card with the Thinking Routine: "See-Think-Wonder" (Harvard Project Zero, n.d.) to each group to support their discussion.

The groups had about 20 minutes to process the words and images of their sub-theme and collectively develop a short performance or sequence of movements inspired by their theme. They were encouraged to use any of the available materials (fabrics, musical instruments, objects) and were able to incorporate music or sounds.

Through movement, concept sketches, or gesture mapping, each group created a body "narrative" that connected the concepts of their sub-theme, the objects or symbols (such as the boat, the suitcase, etc.) and the emotions evoked by the works of art. This process allowed them to deepen their understanding of the refugee experience through creative, embodied dialogue within the small group setting.

5.3. Stage 3: Creative Interpretations

In the third stage, each group presented to the other participants the short, embodied performance they had prepared. For example, the "blue" team physically reenacted the act of leaving home and boarding a ship, while the "yellow" team portrayed a mixture of sadness and resilience symbolized by the transport of a suitcase to a new homeland.

As each group presented its work, the other participants acted as spectators, observing how abstract concepts and emotional themes were translated into body expression. These performances allowed everyone to witness multiple interpretations of the refugee experience, each highlighting different aspects through the use of gestures, posture, space, and movement.

The stage of creative interpretations often provoked intense emotional reactions, both in the performers and the audience, as participants connected empathetically with the stories being performed through the body.

5.4. Stage 4: Conclusion and Reflection

In the final stage, all participants gathered for a collective closing and reflecting activity. We gathered again in a circle, while percussion sounds played in the background (a piece by Greek musician Boulgourtzis (1996) whose music combines Eastern and Western elements). While a final narrative excerpt from the 1922 refugee testimony was read, describing a scene in which a barefoot refugee child plays an improvised drum, gradually drawing others into a communal dance, the participants spontaneously began to join in, clapping their hands or moving gently to the rhythm. They were then given small percussion instruments (such as tambourines and wooden clappers), and the group began to respond to the music with synchronized movements and improvised rhythms, symbolically representing a moment of collective catharsis and hope. After this climax, we guided the group through a short sequence of relaxing movements and breathing exercises to release any tension.

A discussion of reflection followed, posing questions such as: "What emotions did you notice emerging during the performances? What did you feel as spectators? If you had been on that crowded pier in 1922, what sensations (touch, sound, sight) do you imagine you would have experienced?" These questions sparked a meaningful dialogue about empathy and connection to the historical experience.

Finally, participants were asked to draw or sketch out a final "embodied" experience or feeling from the workshop, without using words, and to share it with the group if they wished. This exercise was intended to support the transition from physical and emotional experience

to cognitive articulation, as participants were invited to express what they learned or felt in the workshop.

The workshop ended with many participants reporting that the process had been profound and enlightening, and that they appreciated the way movement and art had been combined to convey the refugee experience.

6. RESULTS OF THE SECOND PHASE DIGITAL QUESTIONNAIRE

6.1. Evaluation of the Workshop's Pedagogical Experience

After participating in the workshop, the sample sub-group of 23 students was asked to complete a new digital questionnaire to record their experiences. Regarding the research question on how they evaluated the workshop, the students agreed that it is an appropriate approach for young children ($M = 4.1$, $SD = 0.62$) because of its playful and creative learning through movement activities ($N = 5$, 26%). It helps children express themselves through the art of theater ($N = 5$, 26%) and helps them to relate emotionally to the subject ($N = 4$, 17.4%). However, they felt that the material needed to be adapted to the age of the children ($N = 6$, 26.1%). Finally, some students pointed out the specificity of the workshop topic, noting that in order for young children to deal with such a sensitive issue, they need to be familiar with it ($N = 4$, 17.4%). The answers to the question about what the participants gained from the workshop showed that they understood the connection and contribution of art and movement to experiential learning and to the comprehension of complex topics ($N = 7$, 30%). Many felt more emotionally connected to the refugee issue ($N = 6$, 26%), gained new experiences for future use ($N = 5$, 22%), and experienced freedom of expression and enhanced creativity ($N = 4$, 17.4%). When asked if they would change anything about the workshop, the majority of participants said they were completely satisfied with it ($N = 14$, 61%).

6.2. Difficulties and Obstacles in Implementing Embodied Learning

In response to the research question regarding the difficulties and obstacles in implementing embodied learning in the workshop, some found it difficult to express emotions non-verbally ($N = 6$, 22%) and to adapt to experiential or theatrical techniques ($N = 6$, 22%). When asked whether there were difficulties in utilizing a movement approach to works of art in museums, 35% of the sample ($N = 8$) ($M = 3$, $SD = 1$) agreed, noting that the main difficulties were lack of space ($M = 4.2$, $SD = 0.99$), consistency in following rules ($M = 4.1$, $SD = 1$), and, to a lesser extent, the security guards ($M = 3.1$, $SD = 1.2$). When asked if there is anything that could hinder the use of the movement approach utilizing works of art in the kindergarten classroom, they agreed that there are difficulties ($M = 3.4$, $SD = 0.9$), such as classroom space ($M = 3.8$, $SD = 1.07$), followed by the lack of technical equipment ($M = 3.21$, $SD = 1.2$), and funding ($M = 3.4$, $SD = 1.07$).

6.3. Perceptions of Embodied Learning and the Experiences Associated with it

Regarding the research question about what the students' perceptions of embodied learning were after the workshop, most students agreed that works of art can serve as a motivation for children's motor activation ($M = 4.56$, $SD = 0.58$) and that through movement and the sensory experience of works of art, we can approach difficult concepts such as the refugee issue ($M = 4.78$, $SD = 0.51$), as this approach stimulates children's imagination and creativity, provides experiential understanding of complex issues through movement, theatricality, and sensory appreciation of works of art, and fosters emotional engagement and

empathy. Finally, most students agreed that the workshop met their expectations ($M = 5$ and $SD = 0.4$) and also added that movement and the experiences associated with it play an equally important role in children's education and learning processes ($M = 4.5$, $SD = 0.5$), children's social development processes ($M = 4.6$, $SD = 0.5$), children's emotional expression ($M = 4.7$, $SD = 0.5$), and their physical-motor development ($M = 4.6$, $SD = 0.4$).

7. DISCUSSION

The findings of this study offer insight into how future kindergarten teachers perceive museums, art, and embodied learning. In their responses, the students-teachers predominantly described museums as places of art, exhibits, and history, a perspective consistent with previous research in Greece (Koufou, 2025; Trouli, 2023; Dimitriadis & Malafantis, 2022; Oikonomidis & Trouli, 2022). The frequent appearance of words such as "statues" and "history" in their associative responses reflects the dominance of archaeological and historical museums in the Greek context (Koufou, 2025; Doxanaki & Linardakis, 2022). Although participants recognized museums as places of learning, exploration, and discovery, they also highlighted significant shortcomings, particularly in the areas of educational engagement and accessibility. This criticism is linked to ongoing calls for museums to become more interactive and inclusive spaces for all visitors, including young children (Hackett et al., 2020; Christofalou, 2021).

The strong support of future teachers for incorporating museum visits and art into preschool education is consistent with the international literature on museum education and the development of children (Mavilidi et al., 2022; Trouli, 2023; Dimitriadis & Malafantis, 2022; Oikonomidis & Trouli, 2022). Participants recognized multiple benefits, from enriched sensory experiences to the development of empathy and cultural awareness, confirming that purposefully designed experiences involving works of art or museums can support the comprehensive development of children (Wu, 2024; Sotiropoulou-Zormpala et al. 2015). These perceptions echo previous findings that visits to cultural sites or the use of art in the classroom can enrich the learning experiences and skills of children (Wu, 2024; Trouli, 2023; Dimitriadis & Malafantis, 2022; Oikonomidis & Trouli, 2022). The near unanimous agreement among the participants on the value of these practices shows that the new generation of teachers is positively inclined to incorporate cultural and embodied experiences into their teaching practices.

The students in this study showed a clear appreciation for embodied learning as a pedagogical approach. They agreed that activating the body through movement can deepen the understanding and memorization of art and concepts, which is in line with the scientific approaches of cognitive science to embodied cognition (Watson & Delaney, 2024; Foglia & Wilson, 2013; Barsalou, 2010), as well as educational research highlighting the effectiveness of movement in the learning process (Kosmas & Zaphiris, 2018; Macedonia, 2019). Particularly noteworthy is their perception that movement can help address difficult concepts, such as the complex and sensitive issue of refugees. This reinforces the idea that embodied methodologies can make abstract or emotionally laden topics more accessible and meaningful by physically and emotionally engaging students (Papadopoulos & Mamali, 2021; Smyrniou et al., 2016). The workshop we implemented is a concrete example of this phenomenon by raising awareness of the refugee experience. Participants were able to "experience" historical and social issues in a safe, guided way, transcending the limits of traditional lectures or discussions.

The feedback from workshop participants further highlights the strengths and conditions of using embodied learning in combination with art. Other studies have reported high levels of student engagement in embodied activities in museums (Hilde & Ørbæk, 2024; Kukkonen, 2022; Hubard, 2007) similarly, our participants found the approach extremely appealing, creative, and effective in cultivating empathy. Many described the workshop as playful but also emotionally powerful, showing that it achieved a balance between joy and depth, which is considered ideal in the educational practice (Vasilaki, 2023; Kai-Kee, Latina & Sadoyan, 2020). At the same time, they were practical, pointing out the need to adapt the material for younger ages and that extra care is needed when working with sensitive topics. This reflects a mature understanding that, even though embodied learning is a powerful tool, its implementation must be age-appropriate and mindful of the context.

Despite the fact that the sample size for the second part of the study was small and that in both phases several of the open-ended questions were not completed by the participants, the results of the study are encouraging for the future of teacher education. They show that the new generation of teachers not only values embodied learning but also museum-based activities. The participants' request for workshops and experiential courses in the university curriculum confirms previous observations that such opportunities are currently lacking (Trouli, 2023; Oikonomidis & Trouli, 2022). By incorporating practical experiences, such as the workshop described in this study, teacher education programs can equip future teachers with the confidence and skills to integrate movement, art, and multisensory experiences into their teaching. In this way, we are moving towards an educational model that treats the body as an ally in learning, a change that is supported both by contemporary theories and by the positive results observed in the field (Kosmas & Zaphiris, 2018; Macedonia, 2019).

8. CONCLUSION

In the context of preschool education, the application of embodied learning is not simply an innovative addition, but an integral part of pedagogical practice that responds to the developmental needs of young children. Young children learn naturally through movement, senses, and active exploration; they "think" with their bodies as much as with their minds (Macrine & Fugate, 2022; Macedonia, 2019; Kosmas & Zaphiris, 2018; Foglia & Wilson, 2013). Our research shows that future kindergarten teachers who participated in our research seem to recognize the value of embodied learning. They identified its benefits for the children's understanding, memory, emotional engagement, and social development and expressed their intention to use cultural resources, such as visits to museums and works of art, as stimuli for learning through movement. It is also important that participants highlighted the need for support and training to be able to implement these methods effectively. The workshop we conducted offers an example of how the education of future kindergarten teachers can provide this kind of practical training, immersing them in a hands-on learning experience that they can later adapt to their own classrooms, considering the particularities of preschool age.

The positive reactions of the participants underscore the potential of the workshop as a positive practice in the education of teachers. By engaging with an emotionally laden topic through art, movement, and dramatization, future teachers not only learned about the topic itself, but also directly experienced how embodied methodologies can cultivate empathy, creativity, and critical thinking. Such transformative learning experiences in teacher education can bridge the gap between theory and practice, ensuring that new teachers feel empowered to draw on the full range of human experiences — body, senses, emotion, and

thought — in the learning process (Sotiropoulou-Zormpala, et al., 2010; Sotiropoulou-Zormpala, et al., 2015; Trouli, 2023).

In conclusion, incorporating embodied learning strategies into both teacher education and preschool classrooms has the potential to enrich learning in a comprehensive manner (Watson & Delaney, 2024; Hilde & Ørbæk, 2024; Macrine & Fugate, 2022; Macedonia, 2019). As the participants' testimonies show, there is both enthusiasm and clear evidence for making movement, art, and sensory engagement key elements in the teaching of young children. Enhancing university programs with experiential courses and embodied learning workshops will prepare future teachers to utilize these approaches, creating more dynamic and inclusive learning environments for the next generation of students.

8.1. Limitations of the Study and Suggestions for Future Research

This study was based on a small sample of 53 future kindergarten teachers from a specific geographical context (Crete/Greece), which limits the generalizability of its results. The limited scope of the research dictates the need to investigate perceptions of embodied learning and approaching works of art in broader and more heterogeneous samples of kindergarten teachers to examine the degree of generalization of the findings.

Furthermore, as the research data were based solely on digital questionnaire responses from participants, future studies would benefit from combining digital questionnaires with classroom observation and analysis of learning activities to capture embodied learning in the classroom.

The non-experimental nature of the research does not allow for causal conclusions. Future research with an experimental design and implementation of interventions could investigate any changes induced in indicators such as empathy, body expression, linguistic development, etc., as well as other complex social or ethical issues such as the refugee crisis.

Furthermore, the workshop was designed and implemented for university students, future kindergarten teachers, not for preschool children. Therefore, it is not directly applicable in kindergarten. Future research should be designed and implemented involving preschool children, taking into account their developmental characteristics and needs.

8.2. Pedagogical Implications in Kindergarten

The findings of this study, although derived from a relatively small sample and subject to methodological limitations, are consistent with the international literature on embodied learning, suggesting positive associations between body expression, motor activation, and the development of empathy in preschool education. In this context, it becomes a pedagogically appropriate choice for kindergartens to gradually and consistently incorporate activities involving art appreciation into their curriculum, including sensorimotor games, body expression, role-playing, and body representations, rather than passive viewing or exclusively oral analysis.

The strong correlation with indicators such as empathy and body expression reinforces the perception that embodied experiential approaches are a multidimensional pedagogical tool which contributes significantly to the comprehensive development of children as early as preschool age.

From the perspective of future kindergarten teachers, the use of movement in approaching works of art in the classroom and during visits to cultural sites is not limited to cognitive benefits but is closely linked to the enrichment of the children's experiences and the approach of complex social issues, as well as the cultivation of civic, cultural, and environmental awareness. This suggests that works of art in kindergarten can serve as a "starting point" for interdisciplinary activities involving the body, language, social and

cultural education, and the environment, rather than merely being an isolated museum object. Each work of art can give rise to body representations, discussions, narratives, rules of coexistence, environmental actions, or even collective decisions in the classroom. However, the wider application and generalization of these embodied approaches require further investigation into their effectiveness in future research.

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