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 foster 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; Fleer, 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 *(Recognizing students' intellectual and emotional engagement in learning, such as excitement, frustration, or curiosity)*	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 *(Seeking to understand and clarify why students think in a certain way, even if their reasoning is unconventional or incomplete)*	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 *(Finding the productive beginnings in students' thinking, even if it's not fully correct yet)*	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 *(Predicting common misconceptions or struggles students might have and preparing ways to support them)*	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 *(Demonstrating genuine interest in how students think rather than just whether they are "correct")*	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 *(Reflecting on one's own learning struggles and using them to empathize with students)*	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 *(Recognizing students' intellectual and emotional engagement in learning, such as excitement, frustration, or curiosity)*	● 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 *(Seeking to understand and clarify why students think in a certain way, even if their reasoning is unconventional or incomplete)*	● 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 *(Finding the productive beginnings in students' thinking, even if it's not fully correct yet)*	● 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 *(Predicting common misconceptions or struggles students might have and preparing ways to support them)*	● 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* *(Demonstrating genuine interest in how students think rather than just whether they are 'correct')*	● 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 *(Reflecting on one's own learning struggles and using them to empathize with students)*	● 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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