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Special Issue Reprint

Agency in Teaching and Learning with Digital Technology

Opportunities and Challenges

Edited by
Irina Engeness and Siv M. Gamlem

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Guest Editors

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Preface

The Reprint "Agency in Teaching and Learning with Digital Technology: Opportunities and Challenges" gathers international research that illuminates how educators and learners can exercise agency in the context of accelerating digital transformation. Motivated by the need to understand how artificial intelligence, automation, and digital media are reshaping education, this collection investigates strategies for empowering teachers and students to act autonomously, ethically, and collaboratively. The Reprint is addressed to researchers, practitioners, and policymakers who are interested in fostering meaningful and equitable engagement with technology in education.

Irina Engeness and Siv M. Gamlem

Guest Editors

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Editorial

Agency in Digital Education: Empowering Students and Teachers in Technology-Rich Learning Environments

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1. Agency in Teaching and Learning with Digital Technology: Why Now?

In the rapidly evolving landscape of digital technology, the imperative for fostering agency in digital learning has become paramount. The unprecedented acceleration of technological advancements necessitates a corresponding adaptability among both educators and learners. As artificial intelligence (AI), automation, and digitally mediated learning environments proliferate, the ability to critically engage with and strategically navigate these tools is indispensable (AACSB, 2024; Education Next, 2024). The digital transformation of education is causing a fundamental shift in pedagogical paradigms, compelling institutions to prioritise the cultivation of digital agency as an essential competency (Brevik et al., 2019; Gamlem et al., 2025; Krumsvik, 2024).

The integration of AI-driven learning assistants, personalised learning environments, and digital pedagogies introduces both profound opportunities and formidable challenges. While such technologies facilitate enhanced engagement, efficiency, and personalised learning trajectories, they simultaneously engender risks of overreliance, diminished critical engagement, and ethical dilemmas (Kasneci et al., 2023; Brookings Institution, 2023). Consequently, digital agency should be understood not merely as digital literacy, but as an expansive construct encompassing critical thinking, self-regulation, and epistemic agency in digital contexts (Siddiq et al., 2024).

Moreover, the exigencies of an AI-driven global economy underscore the necessity of reconfiguring educational approaches to align with emerging professional landscapes. The future workforce will demand individuals who can critically evaluate AI-generated content, responsibly employ digital tools, and retain human oversight in an increasingly automated world (University of Illinois, 2023; Salish Current, 2025). Without a concerted effort to cultivate agency, students risk assuming passive roles as consumers of digital content rather than becoming engaged, autonomous learners. Likewise, the digital agency of educators opens up opportunities to effectively mediate and guide student interactions within these evolving educational ecologies.

2. Theoretical Foundations of Agency in Teaching and Learning with Digital Technology

Agency in digital learning is conceptualised through a multiplicity of theoretical lenses, each elucidating distinct dimensions of autonomous engagement and transformative capacity. Drawing upon socio-cultural, cognitive, and transformative learning theories, digital agency is fundamentally predicated upon the capacity of individuals to exercise intentionality, autonomy, and reflexivity in their interactions with digital technologies.

Vygotsky's Cultural–Historical perspective foregrounds the mediated nature of cognition development, asserting that digital tools function as mediators of intellectual development (Engeness & Lund, 2018). By expanding upon this premise and taking an Activity Theory approach, digital agency is situated within broader systemic interactions, wherein individuals, artefacts, and institutional structures coalesce to shape learning processes (Engeström, 1987).

A particularly salient construct within this discourse is transformative agency, which transcends functional digital competence by encompassing the ability to critique, modify, and innovate within digital environments (Aagaard & Lund, 2019). It necessitates not only technical proficiency, but also the epistemological and ethical discernment to challenge prevailing digital norms and structures (Mouta et al., 2024; Siddiq et al., 2024). Given the pervasive integration of AI in educational domains, the development of transformative digital agency is imperative to ensure that individuals do not merely adapt to technological paradigms, but actively contribute to shaping the trajectory of digital learning and digital technology itself (Engeness & Gamlem, 2025).

As education systems grapple with the affordances and constraints of digital transformation, fostering agency among both students and educators is essential. In subsequent sections, this editorial will elucidate the conceptualisations of student and teacher agency as presented in contemporary research, culminating in a discussion on strategies to enhance digital agency within educational ecosystems.

3. Conceptualising Student Agency in Digital Learning

Student agency in digital learning refers to the ability of learners to make informed choices, set learning goals, and regulate their engagement with digital tools. Studies indicate that student agency is closely linked to motivation, autonomy, and digital literacy (Goriss-Hunter et al., 2022). Digital environments may facilitate student agency by offering interactive, flexible, and personalised learning experiences (Wahyuni & Ariyanto, 2024). However, these benefits are not automatic and require intentional pedagogical design (Kure et al., 2023). Students are less likely to exercise agency when digital tools are used passively or when teacher guidance is insufficient (Lantz-Andersson et al., 2022).

A recurring challenge in fostering student agency is ensuring equitable access to digital learning opportunities. Kure et al. (2023) found that while Norwegian secondary students frequently used technology for basic tasks such as internet searches and document creation, higher-order digital skills such as critical evaluation and collaboration were underdeveloped. Similarly, it is argued that while students appreciate autonomy in digital learning, structured guidance remains essential to help them navigate complex digital environments effectively (Damşa et al., 2021; Goriss-Hunter et al., 2022; Kimber et al., 2002).

To enhance student agency, educators are encouraged to incorporate scaffolding strategies that balance autonomy with structured support (Engeness & Gamlem, 2025). Project-based learning (PBL) and inquiry-based learning (IBL) are particularly effective in promoting a type of student agency that positions students as active agents in their learning process. Studies show that when students engage in design-based projects, such as multimedia creation or digital storytelling, they exhibit higher levels of engagement and agency (Goriss-Hunter et al., 2022; Stenalt et al., 2024). Additionally, digital platforms that allow students to customise their learning paths, such as Massive Open Online Courses (MOOCs), may further support student agency by fostering self-directed learning (Rasa et al., 2024).

4. Conceptualising Teacher Agency in Digital Learning

Teacher agency in digital learning refers to the ability of educators to integrate digital tools effectively, adapt pedagogical strategies, and critically engage with digital policies and resources (Korhonen et al., 2024; Novoa-Echaurren, 2024). Research suggests that teacher agency is influenced by institutional support, professional development opportunities, and the digital self-efficacy of teachers (Mouta et al., 2024; Wahyuni & Ariyanto, 2024).

During the COVID-19 crisis, teachers demonstrated significant digital agency by adapting to remote instruction despite limited prior experience (Damşa et al., 2021; Gudmundsdottir & Hathaway, 2020). Damşa et al. (2021) categorised the digital agency of teachers into three profiles: (i) those who passively replicated traditional teaching online, (ii) those who experimented with digital tools but faced challenges, and (iii) those who fully embraced the digital learning transformation. These findings underscore the importance of digital competence and professional development in fostering the digital agency of teachers (Engeness & Gamlem, 2025; Kimber et al., 2002; Korhonen et al., 2024).

However, it is argued that teacher agency is not only about using digital tools, but also about shaping educational policies and institutional practices (Aagaard & Lund, 2019). Teachers who engage in professional learning communities and reflective practice discussions are more likely to develop a strong sense of digital agency (Lantz-Andersson et al., 2022; Singh & Engeness, 2021). Collaborative discussions help teachers to refine their pedagogical approaches, share successful digital strategies, and navigate the challenges associated with digital transformation (Novoa-Echaurren, 2024; Stenalt et al., 2024).

5. Enhancing Student and Teacher Agency in Digital Learning

In times of rapidly evolving technological changes, fostering agency in digital learning necessitates an integrative and multi-faceted approach that synthesises pedagogical, technological, and institutional strategies. Digital agency, understood as the capacity to navigate, adapt to, and critically engage with digital technology, is central to both student and teacher empowerment in contemporary educational settings. Effective digital learning environments should not merely facilitate access to technology, but actively cultivate learner autonomy, self-regulation, and epistemic agency through structured pedagogical interventions.

For students, scaffolding techniques such as guided inquiry, formative assessment, and personalised learning pathways serve as crucial enablers of self-determined learning, fostering their capacity to learn (Goriss-Hunter et al., 2022). The integration of adaptive learning technologies, interactive digital tools, and multimodal resources allows students to exercise greater control over their learning experiences while engaging in self-directed exploration, problem-solving, and critical reflection (Engeness & Gamlem, 2025; Kimber et al., 2002). Moreover, digital learning environments that incorporate collaborative knowledge-building activities, such as peer review, co-creation, and participatory digital media production, further reinforce agency by positioning learners as active participants in the learning process rather than passive recipients of content (Singh & Engeness, 2021).

For educators, the cultivation of digital agency extends beyond the acquisition of technical proficiency to encompass critical engagement with digital pedagogy, ethical considerations, and reflective practice (Korhonen et al., 2024; Mouta et al., 2024). Effective professional development should prioritise the development of pedagogical adaptability, digital decision-making, and an awareness of the socio-cultural implications of technology use in education. This requires a shift from one-off training sessions towards sustained, collaborative professional learning communities where teachers can experiment with digital tools, share best practices, and engage in critical discourse on technology-enhanced pedagogy (Rasa et al., 2024; Stenalt et al., 2024).

A growing body of research suggests that teacher agency in digital learning environments is closely linked to perceptions of autonomy, professional identity, and institutional support (Kimber et al., 2002; Stenalt et al., 2024). Educators who perceive digital technology as a tool for pedagogical innovation and professional growth, rather than as an externally imposed mandate, demonstrate a greater willingness to experiment with digital teaching strategies and integrate technology in ways that align with their pedagogical values (Damşa et al., 2021; Gamlem et al., 2025). However, structural and organisational factors, such as institutional policies, leadership practices, and workload constraints, can significantly impact the ability of teachers to exercise agency in digital transformation efforts (Korhonen et al., 2024; Littlejohn, 2023).

One of the most effective strategies for fostering teacher agency is engagement in reflexive practice, wherein educators systematically analyse their teaching approaches, evaluate the effectiveness of digital interventions, and iteratively refine their strategies based on empirical evidence (Lantz-Andersson et al., 2022). Research highlights the value of using recorded teaching sessions, structured self-assessment frameworks, and collaborative discussions to enhance digital competence and promote pedagogical reflection (Novoa-Echaurren, 2024). Additionally, professional learning networks that facilitate knowledge exchange and mentorship opportunities further empower educators to develop digital confidence and instructional agility (Mouta et al., 2024; Stenalt et al., 2024).

Ultimately, enhancing digital agency among both students and educators requires a systemic commitment to embedding pedagogical, technological, and institutional support structures that encourage exploration, critical engagement, and self-determined learning. By fostering environments that prioritise autonomy, reflective practice, and professional collaboration, educational institutions can enable both learners and teachers to navigate and shape digital learning landscapes in meaningful and transformative ways.

6. The Special Issue

The contributions in this Special Issue collectively advance our understanding of agency in digital teaching and learning by examining its multifaceted manifestations across diverse educational contexts. The studies highlight how agency is conceptualised, operationalised, and nurtured, offering valuable insights for researchers, educators, and policymakers. Below, we synthesise the key themes and propose strategies to enhance agency, drawing on the empirical and theoretical work presented in this Special Issue.

6.1. Conceptualising Agency in Digital Environments

The studies in this Special Issue conceptualise agency as a dynamic, relational construct that emerges through interactions between individuals, digital tools, and socio-cultural contexts. Aravantinos et al. (Contribution 1) and Engeness et al. (Contribution 3) frame *student agency* as the capacity of learners to act autonomously, make informed choices, and critically engage with digital tools, while, e.g., Hollenstein et al. (Contribution 5) emphasise agency as the ability to explore, problem solve, and assert ownership over learning, particularly in playful or interactive digital settings. Meanwhile, *teacher agency* is explored as the ability of educators to adapt pedagogical strategies, critically evaluate digital tools, and shape institutional practices (Contribution 8; Contribution 11). Furthermore, it is demonstrated how professional development programmes can empower teachers to integrate technology flexibly, aligning with their pedagogical values (Contribution 2).

Theoretical frameworks such as Cultural–Historical, Cultural–Historical Activity Theory (CHAT) (Contribution 3; Contribution 8), and socio-material perspectives (Contribution 10) underscore agency as mediated by tools and shaped by systemic structures. These lenses reveal tensions such as the "tertiary contradiction" between e-textbooks and traditional teaching roles (Contribution 8), while also highlighting opportunities for transformative engagement.

6.2. Strategies to Enhance Agency

These studies collectively identify several strategies for fostering agency in digital learning environments. Active learning approaches such as project-based learning (Contribution 1) and inquiry-based tasks (Contribution 11) position students as co-creators of knowledge. For instance, Aagaard et al. (Contribution 11) show how simulated parent–teacher conferences encourage critical reflection and problem solving among student teachers. Scaffolded autonomy, which balances structured guidance with opportunities for self-direction, is another key strategy, as seen in AI chatbot-supported MOOCs (Contribution 3) and customised digital portfolios (Contribution 7).

Supporting teacher agency requires professional learning communities that foster collaborative reflection and mentorship, as demonstrated in Kenyan teacher training (Contribution 2) and in simulations in Norwegian teacher education (Contribution 11). Institutional empowerment is also critical, as addressing systemic barriers—such as policy gaps and workload constraints—enables teachers to innovate (Contribution 4; Contribution 8). Ethical and inclusive design further enhances agency, with tools like the artificial intelligence machine learning system (AI-MLS) (Contribution 9) and #BookTok (Contribution 6) illustrating how technology can amplify marginalised voices while mitigating biases. Ensuring equitable access to digital resources remains a priority (Contribution 4).

6.3. Contributions of the Special Issue

This Special Issue makes three key contributions to the field. First, it advances theoretical frameworks like Cultural–Historical, CHAT, and Technological Pedagogical Content Knowledge (TPACK) by integrating agency as a central component of digital learning. The empirical studies provide robust evidence for these theoretical extensions across diverse educational settings.

Second, it provides empirical evidence of how agency can be fostered through pedagogical innovation, professional development, and institutional support, confirming the core principles from Siddiq et al. (2024) while offering new, context-specific implementations from primary to higher education across multiple continents.

Finally, it highlights the importance of equity and ethical considerations in designing digital learning environments that empower all participants, taking forward and operationalising ethical frameworks. The focus on marginalised voices through tools like #BookTok (Contribution 6) and adaptive technologies for learners with disabilities (Contribution 7) represents particularly significant extensions of prior equity-focused research.

In conclusion, the studies in this Special Issue collectively underscore the transformative potential of agency in digital education while demonstrating how contemporary research both confirms foundational findings and pushes theoretical and practical boundaries. By fostering environments that prioritise autonomy, critical engagement, and collaborative learning, educators and institutions can empower both students and teachers to navigate and shape digital learning landscapes in meaningful ways. Future research should continue to explore the interplay between agency, technology, and pedagogy, ensuring that digital education remains inclusive, adaptive, and empowering for all learners while building upon the robust foundations established in this Special Issue.

Conflicts of Interest: The authors declare no conflict of interest.

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Systematic Review

Educational Approaches with AI in Primary School Settings: A Systematic Review of the Literature Available in Scopus

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Abstract: As artificial intelligence (AI) becomes increasingly prevalent, it has become a topic of interest in education. The use of AI in education poses complex issues, not only in terms of its impact on teaching and learning outcomes but also in terms of the ethical considerations regarding personal data and the individual needs of each student. Our study systematically analyzed empirical research on the use of AI in primary education, specifically for children aged 4–12 years old. We reviewed 35 articles indexed in SCOPUS, filtered them according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, analyzed them, and categorized the findings. The research focused on the studies' objectives, learning content, learning outcomes, learning activities, and the pedagogy of activities or the AI tools. Our categorization resulted in three main categories of research objectives regarding the creation, implementation, and evaluation of AI tools and five categories for learning content: AI and ML (machine learning) concepts in STEM and STEAM, language learning, mathematics, arts, and various other subjects. The learning activities were split into four categories: apply, engage, interact, use; project-based learning with multiple activities; experience and practice; and students as tutors. The learning outcomes were split into three levels: cognitive, affective, and psychomotor. The pedagogy of AI tools falls into four categories: constructivism, experiential learning, AI-assisted learning, and project-based learning. The implications for teacher professional development are discussed.

Keywords: artificial intelligence; AI education; AI applications; primary school; preschool; kindergarten; systematic review

1. Introduction

The term "artificial intelligence" (AI) can be defined in sufficient detail by encompassing its various aspects, which include the ability to achieve complex goals in complex environments, the explanation and simulation of intelligent behavior with computational processing in the context of rationality and logical reasoning, and the demonstration of behavior and intelligence that simulates human behavior and intelligence to achieve specific goals [1,2]. From the outset of AI, there has been a connection with the field of education that was driven by the desire of its pioneers to link AI to the learning process, to understand both how AI and learning work, as they emphasized the importance of cognitive science for the development of AI for educational purposes [3]. Nowadays, as the impact of AI increases and permeates more areas of our daily lives, the scientific field of education can not remain unaffected. Therefore, a rise in artificial intelligence in education (AIEd) research has been observed [4,5].

Additionally, over the last five years, some systematic reviews have tried to figure out the trends of AI and its educational implications. Specifically, Younis et al. [6] examined the applications of robots and natural language processing in education by studying 82 scientific articles from 2014 to 2023 with students of all ages. Even though their systematic review suggests that these technologies can provide feedback and personalized instruction, facilitate collaborative learning or critical thinking, and promote inclusivity, student engagement, and teacher support, they have not focused on learning content and activities or pedagogy of the AI applications. İpek et al. [7], in their systematic literature review of educational applications of ChatGPT with 40 studies from December 2022 to February 2023 and unspecified student ages, categorized ChatGPT's use into positive and negative themes and focused on the implications, challenges, or potential effects of integrating ChatGPT into education and not on its pedagogical use or learning approaches. Positive use, relative to the education field, includes abstracting, literature review, generating literature, translation, and paraphrasing, generating complex and deep answers for exams, identifying students' needs earlier, personalized learning experiences, grading and assessment, data analysis, prevention of cybercrime and cyberbullying, helping people to study, etc. On the other hand, potential problems with the use of ChatGPT can be cheating, creating bias, generating incorrect answers, and legal and ethical issues.

More related to our research aim are the following reviews. The systematic literature review on teaching and learning machine learning (ML) by Sanusi et al. [8] was not limited to a specific year range of research for its 43 articles, and even though about half included our target age of participants, it focused partly on pedagogy and not at all on learning activities or outcomes. The research explored ML teaching and learning in K-12 education from four development perspectives: curriculum, technology, pedagogical approaches, and professional development. The findings revealed that there needs to be more research on curriculum development, teacher professional development, and training in the context of ML. Additionally, there is a need for more ML resources for preschool and middle school levels and further evidence of the societal and ethical implications of ML.

Furthermore, Yim and Su [9], in their scoping review of AI learning tools in K-12 education with 46 studies from 1995 to 2023, more than half of which related to the preschool and primary school ages, focused on learning tools, learning outcomes, and the significance of innovative pedagogical strategies involved, but were mainly engaged to the context of AI literacy, exploring the way AI should be taught and not the way of teaching with AI. The review by Su et al. [10], which aimed to examine the thematic and content analysis of 16 empirical papers from 2016 to 2022, also identified challenges and opportunities emerging in digital literacy in early childhood education (ECE). However, although it addressed the learning content, pedagogies, and learning outcomes, it did not analyze the learning activities or consider students aged 6 to 12. The results point out challenges like teachers' need for more AI knowledge, skills, and confidence and the lack of teaching guidelines or an appropriate curriculum design; on the other hand, they point out opportunities for students to enhance digital literacy skills and attitudes. Su and Yang [11] also conducted a scoping review. They analyzed 17 studies from 1995 to 2021 about AI in ECE regarding research methods, AI tools and knowledge, activities, and impacts on teaching and learning. The researchers demonstrated improvements in teaching and learning, but more research is needed on AI tutoring systems for younger students. Although the review focused on ECE, AI literacy, and learning activities, there was no reference for the learning content or learning outcomes. The literature review of 39 papers from 2018 to 2022 by Crescenzi-Lanna [12] about human–machine cooperation in education and its ethical implications was also concentrated solely on ECE; it noted that AI challenges are present in ECE in terms of data privacy, and it also examined other aspects of AI in educational settings such as data collecting and processing and predicting events related to students' success and assessment, but it did not mention any pedagogical or learning aspect.

This work aims to present a systematic review providing valuable insights about the research trends for the educational applications of AI in preschool and primary school (age range 4 to 12). With this systematic review, we will cover the scarce presentations about the pedagogical approaches of AI in education in previous systematic literature reviews and the lack of empirical evidence for the students of our target age. Previous systematic literature reviews to date are limited and have either focused scarcely on different aspects of AI, involved a broader or narrower age range of students, or partially addressed the learning dimension, so we focused on filling this gap. A pedagogical approach to the integration of AI into educational environments can be the catalyst for redesigning the curriculum and transforming teacher education, as educators not only have positive attitudes about implementing AI in the classroom and its positive outcomes, but they are also willing to enhance their knowledge and skills with professional training [13]. Through adopting innovative pedagogical approaches with AI technology, it will be possible to establish new practices that optimize teaching processes and meet students' individualized needs to assist them in acquiring essential skills like critical thinking and problem-solving [14]. With all this ongoing development of existing and the design of new tools, the educational system is on the verge of a significant shift that will affect future approaches [15]. Educational policymakers, educators, counselors, and other stakeholders such as parents, local communities, and students are affected by all these rapid changes, so the scientific community should be ready to provide the needed answers.

2. Research Objectives and Questions

We aimed to systematically review empirical articles related to the educational implementation of AI in preschool and primary education and to examine the latest trends in the research field. More specifically, we explored the SCOPUS-indexed literature on integrating AI into education settings for our age group with a pedagogical focus. The age range includes students from early childhood education (4 years old) to the upper grade of primary school (12 years old). This paper will focus on (a) the research objectives of the articles reviewed, (b) the learning content, (c) the learning activities, (d) the learning outcomes, and (e) the pedagogy of the activities or the AI tools used. The research objectives refer to what the authors of each study state about their aim for conducting the specific research, and the learning content refers to the specific lesson, course, or subject being taught with the aid of AI [11]. The learning activities refer to the activities that students engage in during the learning process, and the learning outcomes refer to what the students are learning regarding cognitive or non-cognitive skills [16]. The cognitive learning outcomes refer to specific skills and knowledge, whereas the non-cognitive learning outcomes include skills like cooperation, communication, critical thinking, problem-solving abilities, and motor skills [10]. The pedagogy of the activity or the AI tool is the one described in the studies for the design of the learning activities or the AI tools that are used in each case and can refer to various pedagogical approaches like direct instruction, inquiry-based learning, design-oriented learning, collaborative learning, interactive learning, project-based learning, hands-on activities, and participatory learning. To design an effective pedagogical model, elements like objectives, content, strategy, group organization, time and space allocation, selection of resources, evaluation, and feedback should be considered [17].

Our research questions were as follows:

RQ1: What are the objectives of the studies regarding the implementation of AI?
RQ2: What is the learning content of the teaching process with AI?
RQ3: What learning activities do students engage in each study with AI?
RQ4: What are the learning outcomes regarding cognitive and non-cognitive skills?
RQ5: What are the pedagogies of the activities or AI tools used?

3. Methods

For our research, we used SCOPUS as a single database with unrestricted access because of its content coverage, its convenience and practicality, and its more trustworthy impact indicators, which cannot be manipulated as easily as those provided by WOS [18]. The choice of SCOPUS has also been decided since it may offer better specialized coverage in this field of human–computer interaction, which is highly relevant to our review [19]. The string query for the search that occurred in January 2024 was the following:

TITLE-ABS ((preschool OR pre-school OR "primary school" OR "elementary school" OR "early years") AND "artificial intelligence" AND (us* OR utiliz* OR implement* OR intervent*)) AND (EXCLUDE (SUBJAREA, "MEDI") OR EXCLUDE (SUBJAREA, "HEAL") OR EXCLUDE (SUBJAREA, "BUSI") OR EXCLUDE (SUBJAREA, "BIOC")) AND (LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cr")) AND (LIMIT-TO (LANGUAGE, "English")).

Figure 1 presents the process of the method we have chosen for identifying and screening the articles, which follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for systematic literature reviews [20]. For the screening process, we used only empirical studies and focused on educational applications of AI in school settings from early childhood to the highest grade of primary school. The index search yielded 194 entries, of which 3 were duplicates, 18 were excluded by title, 32 by abstract, 58 were unavailable, and 1 was unreachable. After removing the above, we ended up with 82 articles, of which 3 were previous systematic literature reviews, 3 were retracted, 2 were not full papers, 16 were theoretical, and 23 referred to technical terms about the computer systems used in AI for education, so they were not directly related. An overview of the final 35 empirical studies that met the inclusion criteria for the review can be found in Table A1.

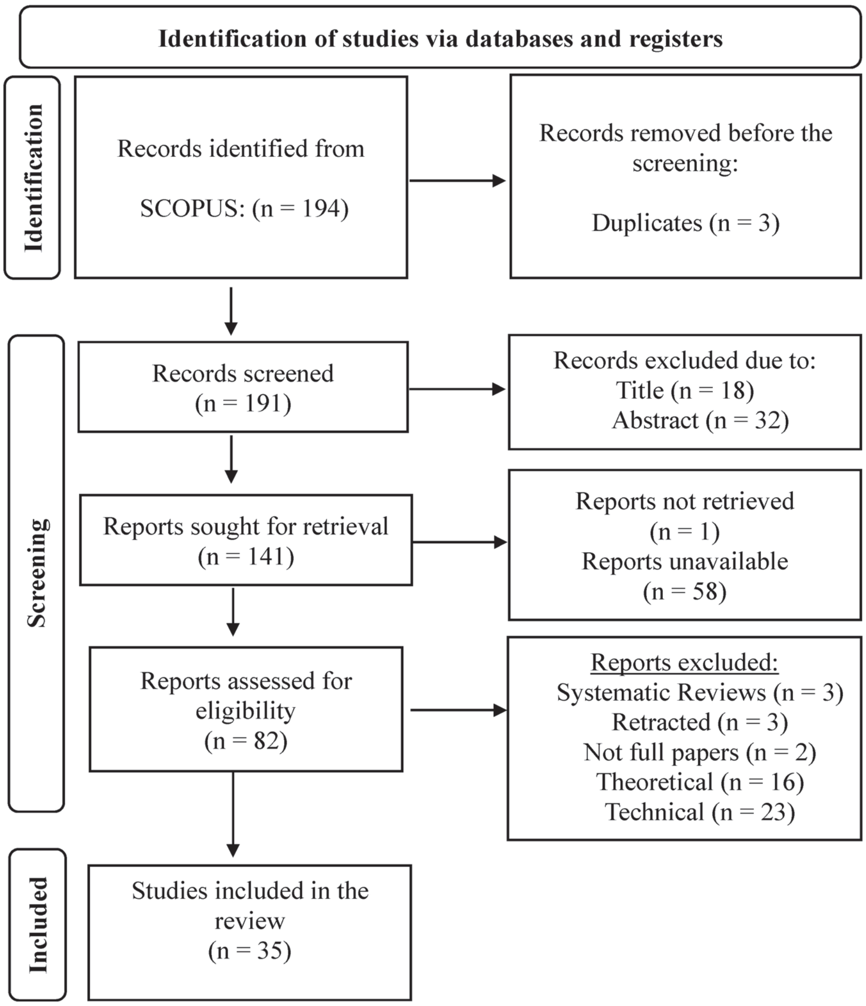

Figure 1. Process of selection of empirical studies.

Journal articles and conference papers of unspecified date were included, although most of the studies were published in the last three years, more specifically, 11 in 2023, 8 in 2022, and 7 in 2021. Papers in languages other than English or unrelated scientific fields such as biochemistry, genetics and molecular biology, business, management and accounting, health professions, and medicine were excluded. The reason we included articles from conferences as well as journals was to allow us to identify the most recent developments being addressed by the research community. The chosen studies had students of our target age as participants. However, we excluded studies with only educators or parents, including those with mixed groups, such as teachers and students (Table 1). Most research took place in China (N = 9), Taiwan (China) (N = 5), South Korea (N = 3), the USA (N = 2), Ecuador (N = 2), Indonesia (N = 2), and Japan (N = 2). Other studies were conducted in Germany, Israel, Singapore, India, the Russian Federation, Bangladesh, Finland, Slovenia, the Netherlands, and Sweden. Asia was the continent with the most research (N = 25), followed by Europe (N = 6), North America (N = 2), and South America (N = 2). Regarding the age of the participants, 27 of the empirical studies had primary school students with ages 6 to 12 as their target, 4 focused on preschool with ages 4 to 6, and another 4 had mixed ages of participant students.

Table 1. Inclusion and Exclusion criteria for SCOPUS-indexed articles.

Inclusion Criteria	Exclusion Criteria
Empirical studies (peer-reviewed)	Systematic reviews and meta-analyses
Studies focusing on implementations of artificial intelligence (AI) in preschool and primary school (students aged 4 to 12)	Studies about AI literacy—teaching AI (except if teaching about AI occurred with the use of AI)
Sample: children in the age range of 4 to 12	Sample: only teachers and/or parents
Scientific fields: computer science, social sciences, engineering, mathematics, psychology, physics and astronomy, decision sciences, arts and humanities, neuroscience, multidisciplinary, materials science, energy, Earth and planetary sciences, chemical engineering, environmental science, economics, econometrics and finance	Irrelevant scientific fields: biochemistry, genetics and molecular biology, business, management and accounting, health professions, medicine
Written in English	All other languages

All the essential data from the 35 eligible articles were extracted using an EXCEL spreadsheet with different themes, where the crucial information was recorded in the appropriate cells, as described by Crescenzi-Lanna [12]. When everything was coded into the spreadsheet, our next step was to look for similar patterns in relevant fields of the studies and perform a thematic analysis to highlight some significant themes by analyzing the data. More specifically, we used the ideas and themes we were investigating to make a coding scheme, which we applied to the data and identified relevant categories within our study fields. We then conducted the analysis where the themes we identified were examined, and we interpreted any connections or distinct patterns among them [21]. Regarding our research questions, the studied categories included (a) the research objectives, (b) the learning content, (c) the learning activity, (d) the learning outcomes, and (e) the pedagogy of the activity or the AI tool.

4. Results

The results of the previous process are presented below for each of the five themes of the studies we focused on for this review.

4.1. Research Objectives

Figure 2 presents the research objectives of the studies, which can be divided into three distinct categories. First and most often, researchers wanted to discover how integrating

AI into education can enhance teaching and improve student learning outcomes. For this reason, new tools to support students were designed, developed, and tested, and existing ones were evaluated. The focus was on different cognitive areas, such as using music programs to enhance creativity [22], the improvement of handwriting with educational Robot Kiddo [23], and the promotion of computational thinking [24] by constructing a design-based STEM + AI teaching model. In addition to these, the development and evaluation of AI-based teaching and learning models like the CP3 in the context of converging multiple subjects were reported [25], and the design of an alternative teaching system for preschool education specialty courses to assist and guide educators to accurately and efficiently retrieve curriculum resources was tested [26]. There was also the development of robotic quiz games to promote self-regulated learning and increased learning engagement [27], in conjunction with AI and its role in promoting cognitive development and physical health of students through interactive learning with “Internet +” and “Big data ML” [28]. In this category, teaching material that integrates AI and ML concepts was constructed in the context of social and science education [29], as well as an ability-oriented STEAM-graded teaching system [30]. AI-based solutions to help identify dyslexia in primary school pupils [31] and AI applications as immersive learning environments that can assist children with Down syndrome [32] were developed. In the form of Natasha Bot, virtual learning partners were created for children with visual impairments [33], to improve their learning outcomes. Research also focused on the innovation of teaching methods and learning systems, with examples of voice assistants being used to assist children in using the toilet independently [34], and the development of intelligent educational and English teaching resources [35]. Completing the first category, we found a program (CAI) designed to assist students’ learning of open-sentence mathematical problems [36] and a recognition learning system for mathematical concepts such as natural numbers [37].

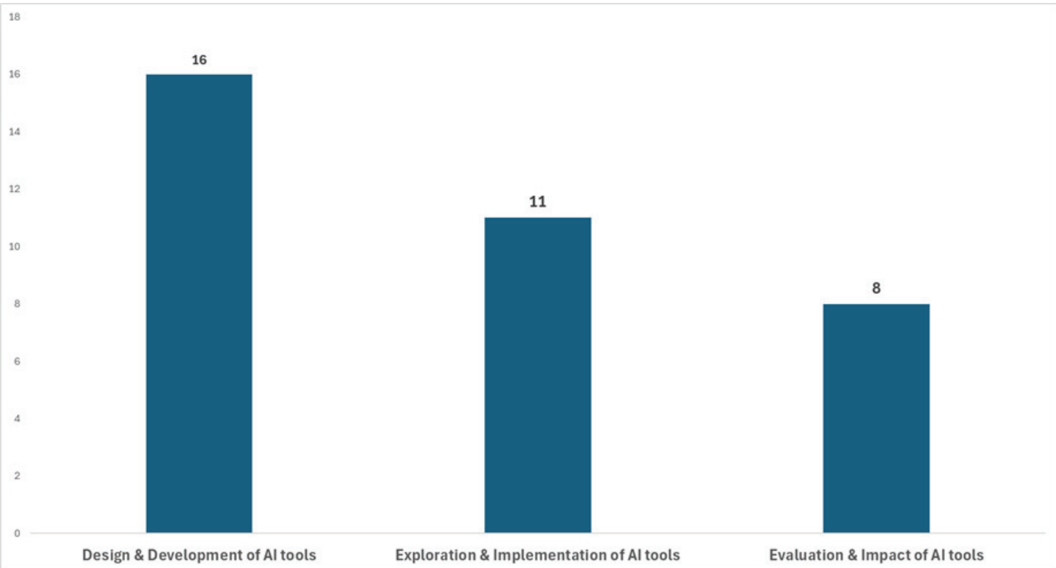

Figure 2. Research objectives.

Moving to the second research category, we included studies that aimed to investigate the implementation of a tool as a teaching aid in terms of learning outcomes, effectiveness, or AI–student interaction. Podpečan [38] examined students’ engagement by investigating their emotional responses, and Williams et al. [39] explored their interactions with social robots to learn about AI. Wu and Yang [40] studied AI science activities in informal curricula on students’ AI achievement, and Chen et al. [41] used an AI-based children’s digital art ability training system to improve their imagination and drawing skills. The motivation to understand and learn ML through programming and computational concepts was accomplished in a constructivist learning environment and with the use of appropriate scaffolds, students managed to construct a neural network in the study of Shamir and Levin [42] which investigated course scaffolds and course outcomes.

Furthermore, personalized and adaptive learning experiences for English language learning and interactions were examined [43] by implementing an AI coach as a humanized agent following the CoI framework [44]. Educational games were also explored to further enhance the learning experiences offered and the engagement in mathematics [45], and Wu et al. [46] analyzed attitude, motivation, and cognitive load on continuous learning intention in STEAM education and learning outcomes associated with AI-assisted educational activities. The impact and the role of AI and robotics regarding teaching and learning practices were also addressed concerning physical development, social–emotional skills, and intellectual growth among students [47] and by identifying the pedagogical and technical considerations when designing teaching interventions with Google Teachable Machine (GTM) [48].

The last category of research was concerned with the evaluation, assessment, and analysis of the impact of AI on children's learning and interactions. The influence of social and emotional intelligence on student character development in educational settings was assessed with the PKES instrument [49], and Neurofeedback technology with the aid of AI was used to analyze the level of attention and temperament of children [50]. Students' perceptions and the process of accepting intelligent machines such as robots were tracked [51], and the influence of AIEd on adolescents' social adaptability and emotional intelligence was studied [52]. Ethical implications were also brought into this category by testing the effectiveness of an AR-based contextualized dilemma discussion approach and by studying concepts such as trust, privacy, and the responsible use of technology [53], as well as an AI-automated analysis of digital storytelling for interdisciplinary learning, with integrated CT skills, for real-time adaptive feedback in STEM education [54]. Finally, Kajiwara et al. [55] examined the educational impact and changes in impressions of AI before and after role-playing the ML process by practicing problem-solving skills and computational thinking, and Bingi et al. [56] facilitated and evaluated learning with AI-based education tools and a humanoid.

4.2. Learning Content

The theme of learning content can be split into four main categories, which contain most of the studies, and a fifth one, which includes many studies with distinct learning contents, as shown in Figure 3.

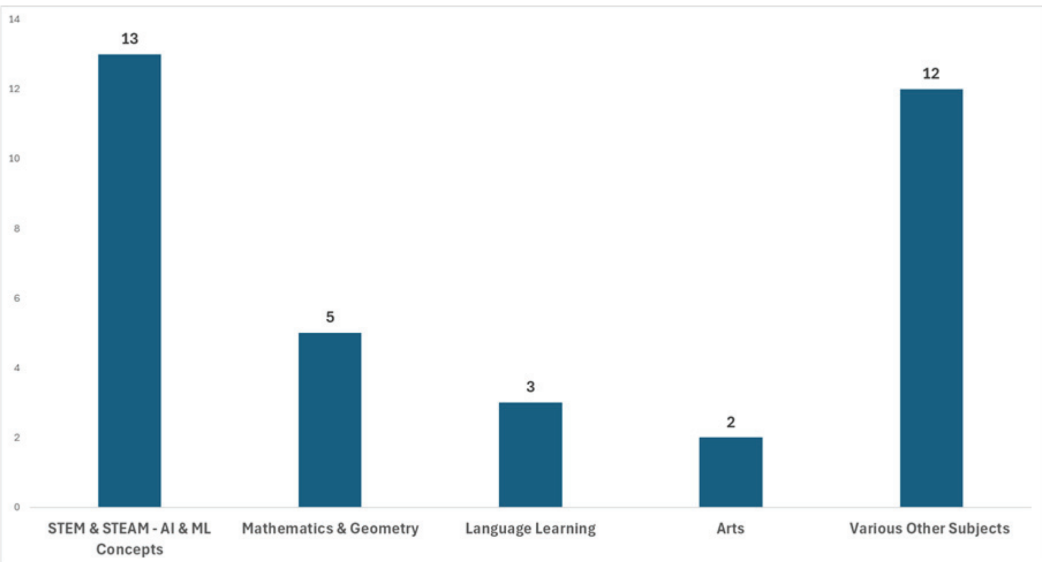

Figure 3. Learning content.

The first category consists of STEM [24] and STEAM concepts [30,46] and AI and ML elements like mechanical expression, perception, reasoning, and consciousness, as well as their integration into educational environments [42,48,55]. Connecting such objects to real-life stories or problems and digital storytelling with incorporated physical science concepts [54], combined with scientific adventures mixing biology and AI concepts [29], can engage students in STEM education. The use of robotics and its applications in education, where robots like NAO bot or Natasha Bot were used as intelligent learning partners for students [38], can also be included here along with engineering, robotics courses, and other STEAM concepts. Learning AI concepts like knowledge-based systems, supervised machine learning, and generative AI [39], as well as sorting network algorithms and data [25], AI knowledge, coding, AI visual applications, and problem-solving through programming [40] or robotics [47], is a final branch of this category.

The second category refers to mathematics and geometry, where children learn basic arithmetic concepts and reasoning by doing and by acting as tutors for teachable agents [45] or are taught to recognize and write natural numbers from 0 to 10 [37]. In this category, students also formulated mathematical questions and added or subtracted numbers with a computer-assisted instruction (CAI) program [36]. Children with Down syndrome were assisted in recognizing or classifying geometric drawings [32]. The development of quiz games with fifth-grade math questions by Weng et al. [27], along with problem-solving abilities and a robot companion, was also found in this category.

The third category includes language learning with an AI coach for speaking and listening [43,44], where researchers were concerned with teaching vocabulary and all its aspects (word, sentence, meaning) in the context of English teaching as a second language. Huang [35] designed and developed educational robot teaching resources using AI to enhance English language teaching.

The fourth category is related to art education, where students can improve their painting performance [41] and enhance their understanding of music theory and harmony [22].

The rest of the studies were scattered among many learning contents, and one instance of each category was found. There is a study that explored ethical dilemmas and the role of educators in implementing AI technology [53] and other studies focusing on environmental issues [56], physical health education [28], or the promotion of children's autonomy with independent toilet training [34]. Omokawa and Matsuura [51] focused on the theme "What is life for me", exploring the moral notions of students about life by interacting with a humanoid, while Khilmiyah and Wiyono [49] explored the emotional and social responses of students with an instrument (PKES) that measured the learning outcomes. Andinia and Isnainiyah [33] accommodated a virtual learning partner to assist students with vision impairment disabilities answer questions from several subjects. Additionally, Mispa and Sojib [23] practiced handwriting and drawing skills with the aid of the robot Kiddo, and Shalileh et al. [31] proposed a robust AI-based solution to identify dyslexia in primary school pupils. Another category that we found is connected to curriculum development and teacher guidance and included topics related to information technology and programming in conjunction with AI specialty courses [26]. Finally, Lee et al. [50] proposed a system to predict and analyze children's temperament and attention levels to investigate possibly hidden cognitive disorders, and Lai et al. [52] aimed to study the influence of AIEd on adolescents' social adaptability through multiple courses from AI curriculum reform experimental schools.

4.3. Learning Activity

The learning activities students engaged in were categorized into four main groups, although they were often interconnected due to overlaps (see Figure 4).

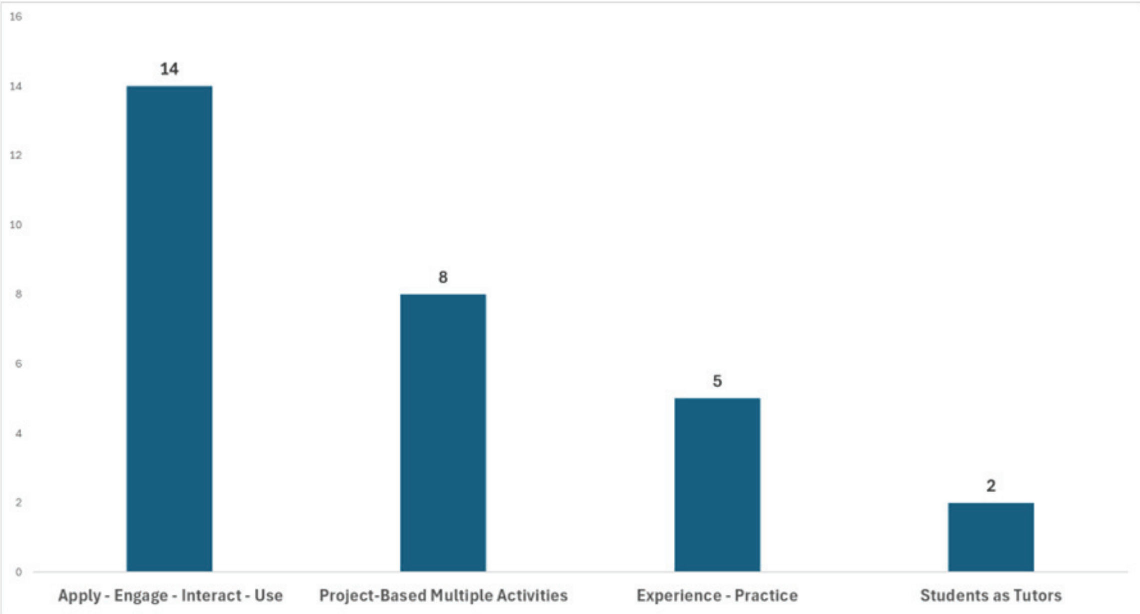

Figure 4. Learning activity.

The first category focuses on interactions with various platforms, tools, or agents, application engagement, participation, and implementation. Thus, Choi [22] examined the music program Doodle Bach to assist students in creating music compositions, Shamir and Levin [42] had students construct an ML-based artifact using a programmable environment, and Barnard et al. [36] used a computer-assisted program (CAI) for students to diagnose problem-solving strategies and their misconceptions. In the study of Gupta et al. [54], students used a learning environment to engage in problem-solving activities and the creation of interactive science narratives, and in the study of Napierala et al. [29], students played with a memory game to identify leaf types in biology, testing decision trees in AI and ML concepts at the same time. There was also an interaction with a virtual environment for children with Down syndrome, using the Leap Motion Controller for kinesthetic engagement [32], and an interaction with a voice agent to guide and support the toilet training process of young children [34]. Bingi et al. [56] referred to interactive learning activities like listening, answering, and receiving feedback from the humanoid NAO, and Wang et al. [43] described an AI coach for EFL learning that aids students in practicing speaking and listening, as well as pronunciation [44]. Additionally, students engaged with the PopBots platform to answer multiple-choice questions [39] and used applications for question-and-answer sessions with Natasha Bot [33]. Participation in math quizzes with the AI robot Zenbo by Weng et al. [27] and writing on a shared whiteboard with the robot Kiddo [23] were also included in this category.

Moving to the second category, we find studies incorporating multiple activities in the form of project-based learning, to provide students with holistic approaches suited to various needs and to enhance their learning outcomes. Here, there were real problem situations that promoted active participation in solving them with peers, and programming and model-building activities for improving computational thinking [30]. In the study of Li et al. [24], students focused on creating scenarios that contained practical problem-solving by designing and implementing solutions to promote scientific literacy and interdisciplinary exploration. In the study of Huang [35], students engaged in role-playing scenario creation, questioning and answering sessions, classroom interactions, group discussions, cooperative gaming, and knowledge carding. In the study of Wu and Yang [40], students were involved in a 6 h AI education program based on the STEM learning conceptual framework and project-based learning, which included teaching sessions, hands-on exercises, group problem-solving activities, and designing and solving problems in real-life scenarios.

Podpečan [38] demonstrated multiple applications: motor development activities and games, children's games, theatrical performances, artificial intelligence applications, and data harvesting applications, based on the main topic and programming techniques for the NAO robot. Joo and Park [25] engaged students with unplugged hands-on activities and natural interaction exercises, for tool exploration and understanding the social impact of AI, as well as with games for the collection and analysis of data, targeting the enhancement of problem-solving and reasoning skills. Students also used web-based tools for an introduction to ML fundamentals, participated in group discussions to exercise critical thinking and creativity, and were assigned a project to work on with Google Teachable Machine (GTM) in the work of Toivonen et al. [48], with the aim of training models and developing applications to conclusively reflect and obtain feedback for their actions. Finally, Wu et al. [46] integrated STEAM with AI into their activities to provide children with hands-on opportunities to create intelligent systems, understand vision recognition, code a program, assemble a game, make graphs, and evaluate and tune correct parameters.

The third category consists of more experiential and practicing activities that can enhance expression and creativity, like observing simulations and role-playing for an inquiry, based on AI issues and ethics in real life [53]. There was also the experience of a machine learning role-playing game (ML-RPG) where students engaged in tasks related to the ML process [55]. In the work of Salas-Pilco [47], students brainstormed, designed advanced robotic models to solve community problems, and presented their solutions, demonstrating social responsibility. Moreover, students collaborated with the NAO robot and its programmer, pretended to be humanoid, watched a movie about care robots, or wrote reflectively in the study of Omokawa and Matsuura [51]. The practice of art painting finally included a series of activities like the creation of the work, the recognition of its technical details, and the experience of an augmented reality (AR)-enriched exhibition of paintings [41].

Lastly, we have two cases where students acted as the tutors for the teachable agent game or the system, interacting with it by playing and answering situation-specific questions [45] or practicing mathematics [37].

4.4. Learning Outcomes

Regarding the learning outcomes, we categorized them into three levels: cognitive skills, affective skills, and psychomotor skills [57], with the focus of the literature being on the affective level. Adopting new desirable behaviors and critical thinking, knowledge acquisition, an overall increase in learning, and presenting a higher quality of work from students are direct observations from the data synthesis. Figure 5 shows the frequency of reports about learning outcomes per level, and Figure 6 presents a word cloud of all learning outcomes.

The first category of affective skills includes reports of social and emotional development of the participants [56], as there was an acknowledgment, appreciation, and management of their emotions [49], as well as an increase in social responsibility and commitment [47], and cooperation with and respect for others in social interactions [30]. Emotional engagement with robotic assistants, empathy for them, and higher levels of learning satisfaction and interest were also recorded [51]. In general, self-efficacy and self-confidence increased as well [47,49], and a shift in students' attitudes to more favorable levels with less anxiety and less fear of accepting AI was observed [55]. In this category, we included autonomous learning [30,35], responsibility, communication [29], collaboration, and increased reports of student engagement [25,37,39,45,46], in line with students' overall improvement in a variety of areas. Students' interest and enjoyment in learning increased, as did their reflective ability and intrinsic and extrinsic motivation [37,41,43,44,46], enhanced attitude [46], and the acquisition of new behaviors with behavioral shaping techniques [34].

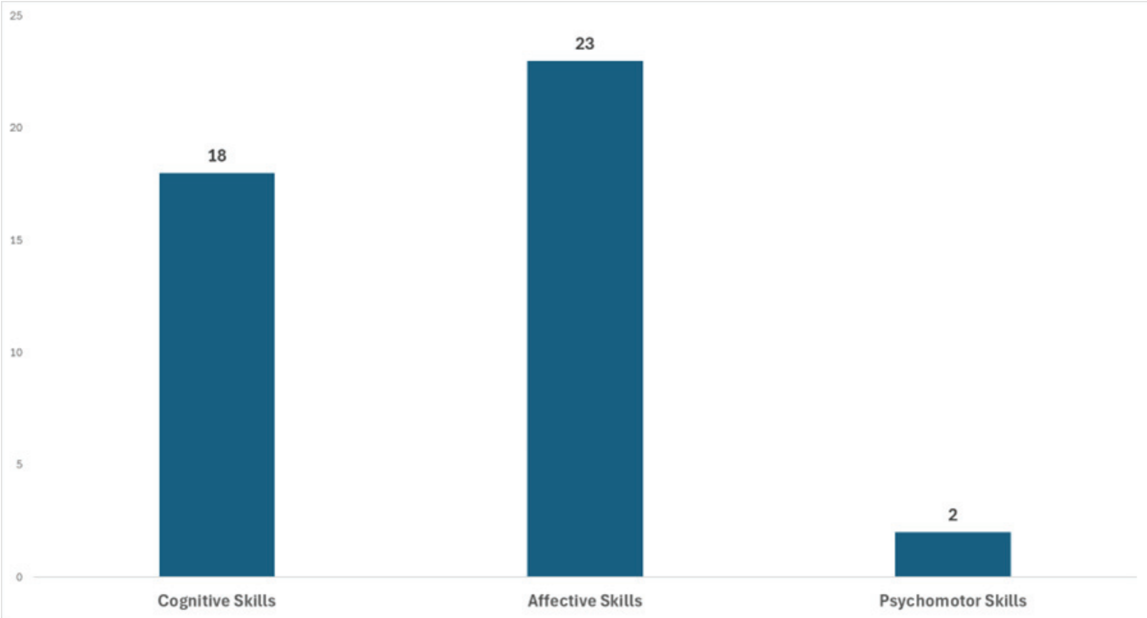

Figure 5. Learning outcomes.

Figure 6. Word cloud of learning outcomes.

Regarding the cognitive level, there were learning outcomes about understanding AI [42], understanding core machine learning concepts and how students use this practical knowledge to train ML models or build applications [48], and understanding computational thinking [25]. Understanding the ethical issues that arise from the use of AI in an educational context [53] was one of the learning outcomes, as were the discussions within the specific bounded context of the possibilities and limitations of technology, especially regarding the perception of robots [39]. The recognition of numbers and geometric figures and the comprehension of the quantities represented by numbers was another learning outcome [32,37], along with proficiency in science concepts and story structuring [54]. With the development of student's ability to solve a problem [34] came the acceptance of AI [55] and insight into processes [36] requiring improved competence and the development of technical skills [46]. Improvement was also observed in many areas, like work quality [40], pronunciation, listening comprehension and vocabulary [44], artistic expression, originality, performance, and creativity [41], music cognitive abilities [22], learning new expressing abilities [24], and technology application ability [27].

At the psychomotor level, there was an improvement reported in the fine motor skills of students, with visual recognition and categorization of geometric figures in mathematics [32], and motor mimicry involving handwriting and drawing skills [23].

4.5. Pedagogy of Activity or AI Tool

Figure 7 shows the pedagogies used in the studies, which we split into four main categories. The pedagogies used were usually mixed, so most studies belong to more than one category.

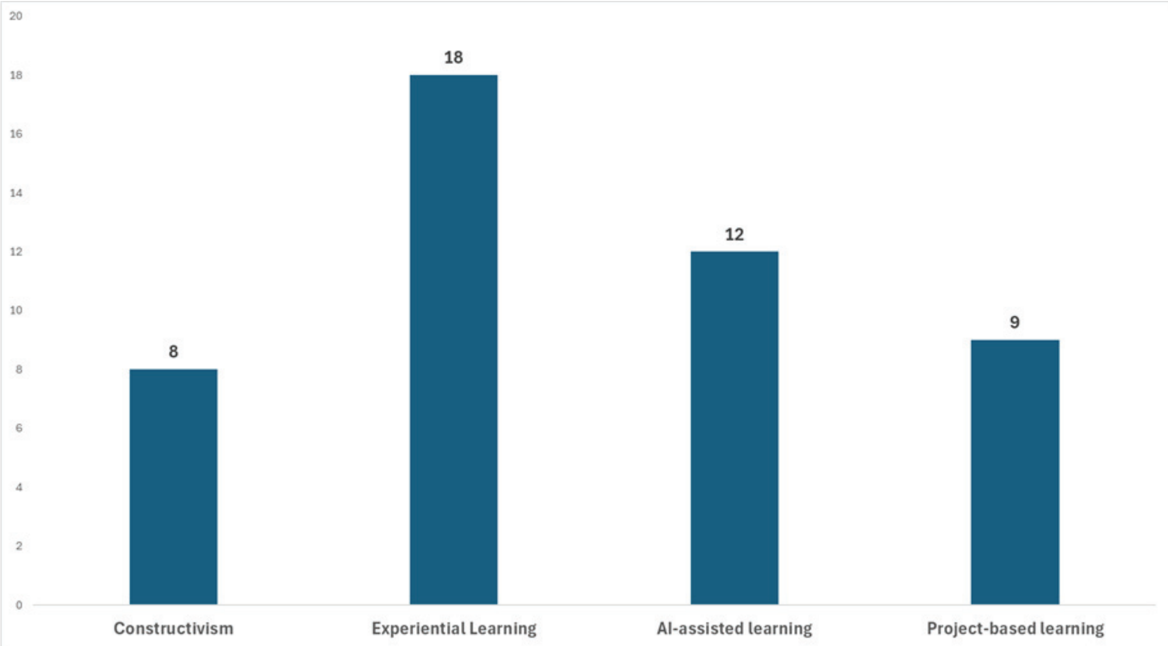

Figure 7. Pedagogy of activity or AI tool.

Among the pedagogical methods used, the most common was experiential learning, with activities adapted to the student's interests, abilities, and experiences and with the employment of immersive environments [32]. Additionally, here, we included problem-solving activities [30,33,43,47], with the exercise of computational thinking skills [25,54], hands-on learning through interactive objects [29,40,47], and interactive narratives [54], as well as role-playing games or scenarios [35,53,55]. In this category, the transfer of knowledge and learning [45,53] and promotion of ethical reasoning skills [53] were also found as means of learning, along with the interaction between students, teachers, and AI [56].

In the second category, technology was used to enhance pedagogical methods. Here, we found social robots as learning assistants [38], adapted to support self-efficacy and self-regulation of learning [27,49], or even taking the role of the learner, positioning the student as the tutor [37,45]. Gamification elements strongly contributed to learning engagement and increased motivation, providing tutoring guidance and feedback [37], and auxiliary teaching systems were used to overcome deficiencies of traditional teaching and enhance shortcomings of existing courses [26]. Collaborative hands-on learning by teaching was also found [23], along with interactive dialogues with AI agents [34]. The involvement of AI in the learning process enhanced interest and upgraded the quality of the material provided [22], emphasized motivation, guided observation and thinking, and encouraged creation [41], personalizing the feedback that was given by the virtual intelligent teacher to each individual learner [44].

In the third category, we found project-based learning, defined by the objectives pursued and implemented by the project method for acquiring STEAM skills [30]. The activities were child-centered, and the research was carried out through project work [47] to resolve the problem and find innovative solutions. Participatory and active learning [39], as well as situational assessment [56], placed the students in truth-seeking scenarios of inquiry [46,53], with the guidance of the AI tools in question. There was also a combination of activities, including lectures, exercises, and group discussions, to come up with a solution [40], or to promote logical reasoning skills on the ethical issues of AI [53], as well as action-oriented learning and design-based research [29].

Lastly, constructivism was another emerging category that stood out as a theory that supports the active involvement of students in the construction of knowledge [24,42,51]. Group collaboration, in conjunction with critical thinking activities, contributed to the acquisition of new knowledge [39], which was adapted to the needs and capabilities of the students [36]. Children became the designers and constructors of their own learning [48], and by reflecting on AI [39], and prompting for self-explanation [45], students managed to refute any misconceptions they may have had.

5. Discussion and Implications

5.1. Relevance with Previous Systematic Reviews

This paper provided insights regarding the research objectives of the relevant studies, which we divided into three main categories according to the researcher's approach to the AI tools. Most of the studies proposed and designed new tools, others implemented and explored their applications, and the least of the studies evaluated their impact on teaching and learning outcomes and students' responses. Some similarities occurred with the systematic review of Sanusi et al. [8] in learning aims, e.g., AI concepts, social robots, games, understanding of ML, and decision trees, and with Su and Yang [11] in assessing the effectiveness of platforms and robots, exploring multiple applications, and investigating their use, children' s perceptions, and learning outcomes.

The learning content of our studies was mainly focused on AI and ML concepts like the learning content reported in [10], e.g., experience machine learning, knowledge-based systems, AI robots, and ethics. Our findings were also focused on language and math learning; however, some of our studies were spread throughout many different subjects, e.g., AI ethics [53], physical health promotion [28], environmental awareness [54,56], children's autonomy [34], moral notions about humanoids [51], emotional and social responses [49], handwriting and drawing [23], learning partner for vision impairment disabilities [33], dyslexia identification [31], specialty courses [26], temperament and attention levels of children [50], curriculum reform [23], and social adaptability [52].

Regarding the theme of learning activities and more specifically the category where students practice and experience simulations, our findings had similarities with those stated in [8] about discussions, role-play, robot and simulation games, scientific inquiry, the use of Google Teachable Machine (GTM), and unplugged activities. GTM was also found in the reviews of Yim and Su [9], Su et al. [10], and Su and Yang [11], along with hands-on activities in [10], for assisting preschool students in their learning of concepts about knowledge-based systems and supervised machine learning. Su and Yang [11] also mentioned the effectiveness of intelligent tutoring systems, problem-solving, peer-to-peer interactions, and creative inquiry literacy, as we also did.

Cognitive learning outcomes like understanding of AI, machine learning, or knowledge-based systems were also reported by Yim and Su [9] and Su et al. [10], along with affective and behavioral outcomes, e.g., motivation, self-efficacy, high student engagement, collaboration, and communication skills. Affective skills were reported more than any other category in our study, in contrast to the review of Su et al. [10] in which only two researchers had designed activities to enhance students' higher-order thinking skills. On the contrary, creative, emotional, and collaborative inquiry were reported as improved skills, although there was no mention of attitudes, motivation, and confidence [10].

Our findings on the theme of pedagogy showed that project-based learning, ML-based solutions, active-based and participatory learning, collaborative methods, and lectures were utilized, as was found in [8]. The most popular pedagogy used in our studies was experiential learning, which in combination with project-based and constructivist methods as interrelated theories, comes in agreement with the findings of the review of Yim and Su [9]. Human–computer interaction and child-centered play-based active learning follow, while the findings in [10] are similar to ours regarding activity-based and experiential learning. Project-based approaches are used less in preschool than in primary schools, while creative inquiry literacy is more suitable for younger students.

5.2. Teachers' Role and Skills

The use of AI and its implementations in preschool and primary education (ages 4 to 12) is an area of growing interest and has experienced significant growth in recent years. Integrating AI in school environments should promote empowering experiences for students and support teachers to further enhance the quality of education. Technology and AI tools aid the teaching process by enriching the learning content and can enhance educators' work, improving students' knowledge and skills. Teachers play a crucial role in facilitating student interactions with AI, guiding and evaluating their use of technology in creative ways. For this reason, educators need to prepare themselves to effectively utilize new AI tools and integrate them into classroom settings to improve learning outcomes [58]. The role, required skills, and perceptions of educators, as well as teacher training for improving knowledge, are expected to be of significant concern for the educational community in the immediate future [59].

Moreover, the development of an AI literacy-implemented curriculum should be organized based on teachers' perspectives and students' needs and provide the appropriate tools to promote learning [60]. On the other hand, the issues raised by the implementation of AI in educational settings are complex, both in terms of its impact on teaching processes and learning outcomes and the ethical dilemmas involved [61]. All stakeholders must be aware of these rapid advancements, and educational policymakers must focus on organizing teacher professional development opportunities and on incorporating AI approaches into curriculum design.

5.3. Suggestions

Considering the importance of teachers for education generally and more specifically for facilitating the interactions of students with AI, educators' AI readiness [62] is vital for the implementation of AI in school settings. Therefore, we suggest the following:

- Focus on teacher training programs and professional development of educators, according to their specific needs. Some topics of interest could be as follows:
    - AI-assisted applications for various everyday class activities and routines;
    - Artificial intelligence, computational thinking, and machine learning basics;
    - Artificial intelligence implications and challenges like AI ethics and inclusivity;
    - AI implementations of platforms and tools, teaching methods and assessment, and curriculum design;
    - Teachers' training should be remunerated, take place during working hours or on educational leave, to surpass any resistance or difficulties and enhance their positive view of technology, ensuring the ethical implementation of AI in preschool and primary school education.
- Further research is needed on implementing AI in preschool (ages 4 to 6) mostly, and primary school (ages 6 to 12), for teaching multiple subjects and addressing students' individual needs.
- Research on implementing AI on various courses and student ages, e.g., adult education, musical instrument courses, AI literacy, history, differentiated learning approaches, and personalized feedback for the tutor and the learner.
- Examine the effectiveness of AI implementation in terms of pedagogical strategies and learning outcomes according to the student's age.
- A theoretical framework and/or policy guidelines for successful AI implementation in educational settings could be developed so that teachers can rely on it to increase the adoption of such technologies in their classrooms.

5.4. Limitations and Future Recommendations

The first limitation of this paper is that the articles that were not accessible at the time of retrieval might contain critical empirical evidence needed for this review. Another shortcoming of this systematic review is that it did not consider other databases and indexes, such as WOS, and it used only literature from SCOPUS. Also, a noted consideration for our research is that the themes we studied are inextricably linked, making it difficult at times to differentiate our findings, due to the size of overlapping information.

Future research could focus on preschool education to provide a more detailed overview of AI approaches and their learning outcomes, or other implications with students of this age. Even though the studies included in this review were disproportionally more about primary school than those focusing on preschool, further research is recommended for all school ages, as we think that the AI curriculum development should be unified for all levels of education. Research should also occur in more countries, and within different educational contexts, as most of the empirical studies that we found were located in Asia, whereas continents like North and South America or Europe had the fewest.

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Appendix A

Table A1. Summary table of all studies and areas of focus.

No.	Reference	Country/ Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
1	Andinia and Isnainiyah (2020) [33]	Indonesia	Virtual learning partner Natasha Bot for people with vision impairment disabilities	Questions about subjects in schools, presented in the form of guessing or trivia	Use the application and engage in a question-and-answer processing session with Natasha Bot	Addressing psychological aspects of learning for individuals with disabilities	Design thinking approach, problem-solving, and user-centered design to create innovative solutions
2	Barnard et al. (1988) [36]	Netherlands	Development of a computer-assisted instruction (CAI) program for open sentence mathematical problems	Elementary mathematics, open sentences in + and -, the identity of the unknown, and the operation sign	Use the CAI Program to diagnose students' problem-solving strategies and misconceptions	Gain insight into problem-solving processes and improve competence in solving such problems	Adapt instruction to the level of individuals by diagnosing their existing knowledge and misconceptions
3	Bingi et al. (2021) [56]	India	Facilitate and evaluate learning among students by using AI-based education tools and humanoid	Stories from NCERT textbooks and environmental science topics from Wikipedia	Interactive learning activities with the humanoid NAO (listening, answering, receiving feedback)	Quality of social interaction; warmth, competence, discomfort, emotional response, feelings for robot	Active learning and assessment, interactive and engaging learning experiences
4	Chauca et al. (2023) [32]	Ecuador	Develop two applications as immersive environments for children with Down syndrome	Geometric figures recognition and classification and performing and recognizing numbers from 1 to 10	Interact with the virtual environment using the Leap Motion Controller to engage with the applications	Recognition and classification of geometric figures and numbers. Improvement of fine motor skills	Immersive environments, interactive learning experiences, supervised learning

Table A1. *Cont.*

No.	Reference	Country/Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
5	Chen et al. (2022) [41]	Taiwan	Improve imagination and drawing ability using a children's digital art ability training system based on AI	Students' cognition of chromatics and enhancement of students' imagination and painting performance	Create work, recognize outline, match hue color, calculate color ratio, view actual AR paintings	Improvement in originality, flexibility, title abstractness, and total scores, imagination and painting performance	Emphasizing motivation, guide observation and thinking, encourage creation
6	Choi (2023) [22]	South Korea	Design, implementation, and effects of an elementary music creation class using AI-based music program	Tonality cognition, rhythm cognition, and melody cognition through the program	Use AI-based music program, Doodle Bach, to create music compositions	Improvements in music cognitive abilities, growth in ability to perceive rhythm, positive impact of sharing creative works and providing feedback	Incorporated AI as an active 'media' in the lesson to engage students and maintain interest in learning
7	Gupta et al. (2023) [54]	United States	Digital storytelling for interdisciplinary learning, science narratives that integrate CT skills	Physical science concepts and energy conversions, aligned with US science standards	Use learning environment, engage in problem-solving activities and create interactive science narratives	Proficiency in science concepts, CT, and story structure. Storytelling and problem-solving strategies	Problem-solving scenarios, interactive narratives, storytelling, physical science, and computational thinking
8	Huang (2021) [35]	China	Design and develop educational robot teaching resources using AI to enhance English teaching	Vocabulary teaching functions. Speech, meaning, example sentence, and unit of a word input by the user	Role-playing scenarios creation, vocabulary teaching, classroom interaction, Q and A, group discussions, cooperative games, word detection and consolidation, teaching review and knowledge carding	N/A	Innovative teaching, autonomous learning, interactive and dynamic learning experiences

Table A1. *Cont.*

No.	Reference	Country/ Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
9	Huh et al. (2022) [34]	South Korea	Develop a service design using AI voice agents to assist in independent toilet training	Using the toilet independently	Interact with an AI voice agent named Ddongddong to guide and support toilet training process	Developed problem-solving abilities and acquisition of new behaviors with behavioral shaping techniques	Interactive dialogues with the AI agent. The agent acts as a practical tool to provide reinforcement
10	Joo and Park (2022) [25]	South Korea	Development and application of an AI-based convergence education teaching–learning model, the CP3	Sorting network algorithm, procedural thinking, sequential structures, and procedural thinking	Implementing the CP3 model, which consists of problem recognition, planning, and play stages	Computational thinking ability, higher satisfaction, interest, and engagement in the AI-based classes	Problem-solving with step-by-step computational thinking skills. Recognition, planning, and play stages
11	Kajiwara et al. (2023) [55]	Japan	Educational impact and changes in impressions of AI before and after role-playing of the ML process	ML process, AI decision criteria, math of ML, decision tree models, and classification results	Experience a machine learning role-playing game (ML-RPG) where they engage in tasks related to the ML process.	Understand ML, skills in perceiving, expressing, reasoning and learning, self-efficacy and acceptance of AI	Hands-on experiential learning through role-playing and interactive tasks
12	Khilmiyah and Wiyono (2023) [49]	Indonesia	Effectiveness of an android-based emotional and social intelligence assessment instrument (PKES)	Emotional and social intelligence aspects, through cognitive, affective, and psychomotor domains	N/A	Recognize, appreciate, manage self-emotions. Social responsibility and cooperation, respect and tolerate others	Use of experimental methods tailored to student interests, abilities, and learning experiences

Table A1. *Cont.*

No.	Reference	Country/ Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
13	Lai et al. (2023) [52]	China	Identify the influence of AIEd on adolescents' social adaptability via social support	IT, general technology and programming courses, flat panel teaching, intelligent reading, assembling robots, 3D printing, Lego plug-ins, teaching boxes	N/A	N/A	N/A
14	Lee et al. (2019) [50]	Taiwan	Predict and analyze the attention levels of children aged 4–7 years old	N/A	N/A	N/A	N/A
15	Li et al. (2023) [24]	China	Construction of a design-based STEM + AI teaching model to cultivate computational thinking	AI robot courses (voice, text, automatic translation, companion, police, shopping guide, and accounting robot)	Focus on the creation of scenarios that lead to the design of tasks related to the intelligent learning partners	Ability to express, ability to question and ability to connect in the context of computational thinking	New knowledge, question asking, collaboration, model building, share and display evaluation feedback
16	Lin et al. (2023) [53]	China	AR-based contextualized dilemma discussion approach to foster students' AI ethics and behavior	AI ethical dilemmas	Observe simulations, inquire about ethics, play different roles, explore AI issues in real-life contexts using AR	Understanding ability for complex AI ethical issues. Contextualized discussing and social interaction	Scenario simulations, in-depth inquiry, transfer learning stages, promote ethical reasoning skills

Table A1. *Cont.*

No.	Reference	Country/ Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
17	Ma et al. (2021) [28]	China	Design and implement a new teaching system for physical health promotion with "Internet +" and "Big data ML"	A user interest model based on DL algorithms, an optimization for health promotion model teaching	N/A	N/A	N/A
18	Mispa and Sojib (2020) [23]	Bangladesh	Robot Kiddo for Interactive Handwriting scenarios by providing a shared environment for writing	100 basic shapes from elementary, grades 1 and 2 textbooks of the National Curriculum and Textbook	Children and Kiddo write simultaneously on a shared whiteboard	Handwriting and drawing skills. Motor mimicry and cognitive development	Interactive handwriting, collaborative hands-on learning by teaching, playful and engaging learning
19	Napierala et al. (2023) [29]	Germany	Develop and test teaching material that integrates AI and ML concepts	AI, ML, and decision trees in computer science, the structure and features of leaves in the biology section	Memory game to identify leaf types, create and test decision trees based on leaf features and unknown leaves	AI-ML, leaf types, decision-making. Communication, biological terms, interactive work, connecting to mathematics	Action-oriented learning and design-based research, hands-on activities, discussions, and reflections
20	Omokawa and Matsuura (2018) [51]	Japan	Development of student notions about life from their dialogs with the humanoid robot NAO	Focus on the theme of "What is life for me?"	Collaborative discussions, watch a movie about a care robot, pretend to be NAO, individual reflective writing	Interest in NAO's mechanical functions. Empathy and emotional connections with NAO	Constructivist educational method, interactive and experiential learning

Table A1. *Cont.*

No.	Reference	Country/ Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
21	Pareto (2014) [45]	Sweden	Teachable agent and engagement in math, mathematical skills and performance	Basic arithmetic understanding, the base-10 number system, fundamental mathematical concepts	Play the teachable agent game and become a tutor to teach the agent, answering situation-specific questions	In-game knowledge to traditional mathematics, engagement, reflection, and explanation	Reflect on decisions, prompt self-explanation, support the transfer of knowledge, and provide a role model
22	Podpečan (2023) [38]	Slovenia	Physical embodiment, anthropomorphism and the emotional aspects in child–robot social interaction	Use of robotics, engineering, and artificial intelligence to engage students in STEM	Develop and demonstrate applications based on the main topic and programming techniques for NAO robot	N/A	Integration of social robots into education and tutoring
23	Salas-Pilco (2020) [47]	China	AI and robotics Impact on learning and teaching activities, physical, social–emotional, and intellectual	AI and robotics technologies to design and create advanced robotic models to solve community problems	Brainstorm solutions, select a key problem, develop a robotic project to address it, and present solutions	Imagining, devising, testing. Self-confidence, teaching, committing, social responsibility, and presenting	Design-based research, integrated analytical framework, hands-on learning, problem-solving
24	Shalileh et al. (2023) [31]	Russian Federation	Propose a robust AI-based solution to identify dyslexia in primary school pupils	N/A	N/A	N/A	N/A
25	Shamir and Levin (2021) [42]	Israel	Course scaffolds and course outcomes in terms of motivation to learn and understanding ML	Machine learning (ML) and the 'machine learning process'	Students construct an ML-based artifact using a novel programmable learning environment (PLE)	Increase in students' understanding of AI concepts and the ML process	Constructionist learning method

Table A1. *Cont.*

No.	Reference	Country/Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
26	Shi and Rao (2022) [30]	China	Propose and realize a novel ability-oriented STEAM graded teaching system for high-quality teaching	Cultivation of diversified abilities with the development of cognitive and non-cognitive skills	Project-based learning in real problem situations, cultivating abilities to solve practical problems	Autonomous learning, problem-solving, critical thinking. Responsibility, communication, cooperation	Reverse design based on the ability goal, project-based learning methods to achieve the desired STEAM abilities
27	Toivonen et al. (2020) [48]	Finland	Investigate the technical and pedagogical feasibility of Google Teachable Machine	Machine learning principles and design of ML-powered Applications using Google Teachable Machine	Conduct co-design workshops, innovate and design ML-powered applications with Google Teachable Machine	Understanding core ML concepts and practical knowledge for training an ML model and build applications	Children as designers and creators in learning process
28	Villegas-Ch. et al. (2022) [37]	Ecuador	Design and create an image recognition system to learn natural numbers between 0 and 9	Recognition and writing of natural numbers 0–9	The child acts as the tutor for the system, interacting with it to practice the numbers	Recognize, write, and understand numbers, comprehend the quantities associated with each number	Gamification for motivation and engagement, system as a teaching aid and tutor for guidance and feedback
29	Wang et al. (2022) [44]	Singapore	AI coach, developed for EFL learning, can support language learning following the CoI framework	English as a foreign language (EFL)	Students listen to sentences read by the AI coach, repeat them, and receive feedback on their pronunciation	Improved pronunciation, listening comprehension, vocabulary. L2 enjoyment, affection for AI	Personalized feedback, virtual intelligent teacher

Table A1. *Cont.*

No.	Reference	Country/ Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
30	Wang et al. (2023) [43]	China	Cluster and epistemic network analysis to provide insights for interaction with AI coach for EFL learning	English as a foreign language (EFL), improve speaking and listening skills, vocabulary learning	Interact with the AI coach for EFL learning, practice speaking and listening, as well as vocabulary learning	Deep, surface and organized approach to learning. L2 learning enjoyment, intrinsic and extrinsic motivation	Feedback, problem-solving, agentic exploration, different approaches, motivation
31	Weiwei (2022) [26]	China	Design an auxiliary teaching system for preschool education specialty courses based on AI	PE course resources, curriculum information and teaching guidance function modules	N/A	N/A	Using AI technology to improve the shortcomings of existing PE courses and enhance the teaching quality
32	Weng et al. (2020) [27]	Taiwan	Develop robotic quiz games for self-regulated learning	Mathematics, specifically designing math questions for the program and reviewing knowledge learned in class	Participate in math quiz games with the AI robot, Zenbo, to review and practice math concepts	Improvement of technology application ability, enhancement of problem-solving, increase in learning	Integration of educational robots to enhance learning of programming and support self-regulated learning
33	Williams et al. (2019) [39]	United States	Interaction with social robots to learn AI	Knowledge-based systems, supervised ML, algorithms' basic functionality, edge cases and initialization	Children engage with the PopBots platform and answer multiple-choice questions	Understanding of AI, prediction and adjustment, perception of robots' autonomy and limitations	Engagement in learning and empowerment to reflect on AI. Participatory learning and critical thinking

Table A1. *Cont.*

No.	Reference	Country/ Region	Research Aim	Learning Content	Learning Activity	Learning Outcomes	Pedagogy of Activity or AI Tool
34	Wu and Yang (2022) [40]	Taiwan	AI science activities in informal curricula on students' AI achievement in popular AI science activities	AI knowledge, coding, AI visual recognition chip applications, and problem-solving through programming	AI education activity based on the STEM learning conceptual framework and project-based learning	Enhanced learning results and creativity, work quality, computational thinking and problem-solving skills	Combination of lectures, hands-on exercises, group problem-solving activities
35	Wu et al. (2022) [46]	Taiwan	Attitude, motivation, and cognitive load on continuous learning intention in STEAM education	STEAM (Science, Technology, Engineering, Arts, Mathematics) concepts and AI concepts	Design an AI-based STEAM game that uses computer vision and controls a robot to play a game	Development of technical skills. Enhanced attitude, motivation, and continuous learning intention in STEAM	STEAM engagement, exploration, explanation, engineering, enrichment, and evaluation

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education sciences

Article

Mobile Smartphones as Tools for ICT Integration in Geography Teaching

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Abstract: This article seeks to reflect on the opportunities that mobile smartphones (MSPs) present as ICT integration tools in teaching geography. The more extensive study, underpinned by the Professional Development Framework for Digital Learning (PDFDL) in ICT integration, employed a qualitative research approach. Lensed by the Professional Development Framework for Digital Learning (PDFDL), the article used the qualitative approach to garner insights from the participants regarding using MSPs as tools to integrate ICT in geography teaching. Data collection tools included interviews, observations, and document reviews. Researchers sampled (n = 4) schools, interviewed and observed (n = 13) teachers, and interviewed (n = 10) learners and (n = 8) parents in the province of KwaZulu-Natal. Furthermore, they used a purposive sampling technique to access the participants, basing the research on the premise that MSPs promote virtual reality for an array of learners. As the findings revealed, although some participants viewed the use of MSPs as a distractor in the learning space, teachers felt compelled to heed the call to modify their teaching pedagogies, such that they integrated mobile phones fruitfully in their teaching. The findings further revealed that such a paradigm shift would benefit homeschooling and facilitate a dual teaching mode at learning institutions. Curriculum planners are responsible for helping teachers accept that uncertainty is the only certainty about the future, considering the volatility, uncertainty, complexity, and augmentation (VUCA) challenges brought on by the COVID-19 pandemic. Extended lockdown periods accelerated the use of MSPs in teaching, requiring every stakeholder in the educational space to become a life-long learner by using a range of technologies and platforms.

Keywords: animation; augmentation; Google Earth; mobile smartphones; tablets; VUCA

1. Introduction

Augmentation and redefinition (AR) in geography teaching and learning are crucial to improving learners' comprehension of challenging concepts and simulating reality for them [1,2]. AR encompasses a wide range of technologies that present computer-generated images in three-dimensional (3D) form (dimension models, text, images, video materials, sound, games, and animations) to simplify reality and thereby benefit the geographer/user [1–3]. Similarly, Ellese Sulistianningsih [4] points out that electronic devices and gadgets of varying kinds appeal to even struggling learners and will serve them well—provided that their emotional intelligence aligns with their required outputs. Slower learners can, without doubt, be accommodated by technology, as most youngsters show some interest in digital devices, no matter how much they struggle with their academic work. This creates an opportunity for teachers and parents alike to factor in learning activities using suitable gadgets to assist, especially those learners who learn at a slower pace. To illustrate, learners are given set-pieces—a compilation of content-based activities that are key to ensuring that they will succeed academically. The materials should be presented in different formats to consolidate the content taught in class. This might occur outside of the normal classroom setting due to the time constraints teachers and learners face in their daily routines [4–6].

In addition, teachers who struggle to work individually with their learners in overcrowded classrooms (a scenario which often sees struggling learners being neglected and falling even further behind) can identify and develop a few highflyers to become mobile smartphone (MSP) champions and serve as tutors of their fellow learners.

2. Theoretical Background

2.1. MSPs Herald a Paradigm Shift in the Educational Space

Geography teachers may use mobile phones by introducing the concept of 'bring your device' (BYOD) for fieldwork [3,7]. They argue that there are dual benefits in promoting learner engagement during fieldwork while allowing teachers to capacitate learners with MSP handling skills [3,6,7]. Many teachers innovatively resorted to using WhatsApp instant messaging to contact their learners during the hard lockdown, when not all school-going children were permitted to attend school daily. Some are doing so even now, with a shortage of floor space and desks in overcrowded classrooms. MSPs have heralded a paradigm shift in terms of how learners communicate. Recent studies revealed that geography learners can use MSPs to perform school-sanctioned activities. As the authors of [2,8] point out, geography teachers may equip their learners with skills to use MSPs to design digital maps. Products created this way can be easily edited, durable, and accessible anywhere and anytime [2,6,8].

However, Alam and Forhad [6]; Chawanji [9], and Hogan [10], warn that some schools' information and communication technology (ICT) policies do not meet teachers' expectations in that they have banned the use of mobile phones on the premises. This practice defeats geography teachers' intentions of capacitating their learners with ICT skills while still at the school level. Therefore, schools are urged to grasp this opportunity and review their ICT policies to become relevant to 21st-century learners in a time when MSPs are omnipresent [6,9,10].

While some learners possess mobile devices, technical problems abound, or they do not have the correct programmes loaded. Instead of focusing on geography-related content, learners may visit other platforms that are not related to the subject. All these issues can hamper the learning process and may cause disruptions in class. For this reason, geography teachers need to upload digital software such as Google Earth-Live Earth map version, onto learners' MSPs to entice them to change their mindsets and regard their digital devices as valuable tools for learning, instead of being sidetracked by them, as shown by Cyclone Idai [11], in Figure 1—where a colourful tropical cyclone can be uploaded onto the MSP, to indicate the presence of an 'eye' at the centre of the tropical cyclone in the Southern Hemisphere.

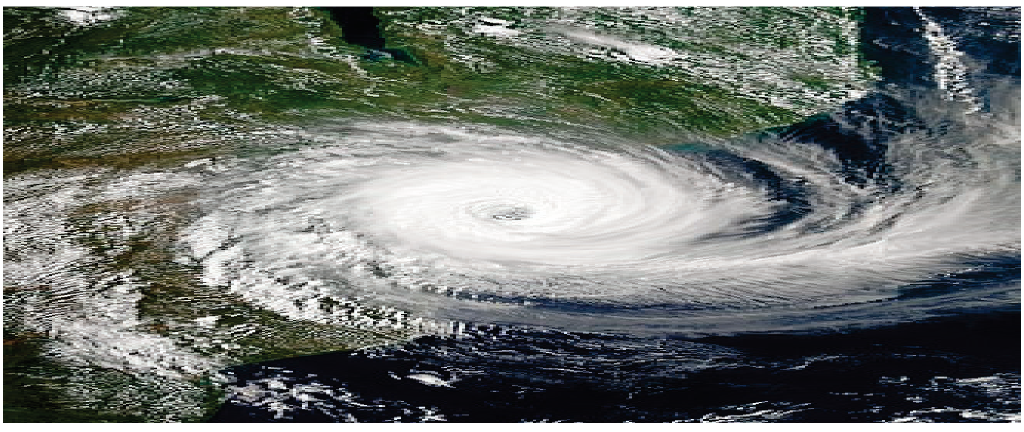

Figure 1. Cyclone Idai. Source: adapted from [11].

Geography teachers may upload valuable aids, such as scanners or global positioning systems (GPS), onto learners' mobile phones to engage learners fully during field trips or other educational excursions [7]. In the same vein, France, Park, Welsh, and Whalley [12] and Volioti, Keramopoulos, Sapounidis, Melisidis, Kazlaris, Rizikianos, and Kitras [2] concede that MSPs are a vital part of the Fourth Industrial Revolution (4IR) and our ubiquitously connected, pervasively proximate (UCaPP) world, and praise the ability of these devices to form part of the pedagogy's teachers use, in the face of uncertainty, to ensure learners' skills development for the future. Technology adoption will allow 21st-century geography teachers to be (and remain) relevant to modern-day learners who are technophiles and whose activities and lines of thought are aligned with ICTs (with MSPs forming part of that equation). Failure by geography teachers to incorporate MSPs in their teaching will add more challenges to teaching and learning processes [12].

Moreover, Voilioti et al. [2] and France et al. [12] are convinced that using MSPs in their teaching allows for the creation of personal learning environments (PLEs) where teachers can customize lessons to meet individual learners' needs. MSPs enable teachers to reach their learners irrespective of either party's physical location and address individual learners' scholastic challenges (academic or socioeconomic), rather than following an umbrella approach where the teacher plans their geography lesson with the whole class in mind. The above scenario implies that geography teachers may be challenged to engage their learners using online teaching strategies, especially when face-to-face teaching in the educational space is impossible [12].

A rethink is thus required, as France et al. [12] further argues that assessments must also be offered online, requiring a new way of monitoring learners during their online assignments. To limit cheating and ghostwriting during assessments, an interconnectedness must be established between hardware and software-such as lockdown browsers to curb online cheating [12]. This will promote more active learner involvement, as indicated in Figure 2.

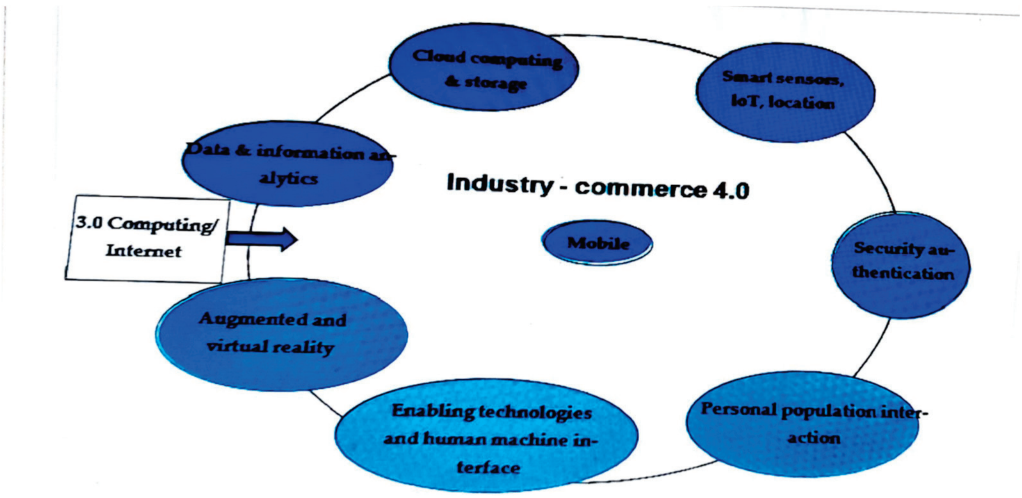

Figure 2. Main features of 4IR. Source: adapted from [12].

2.2. MSPs as an Alternative to Geography Textbooks

According to France et al. [12], MSPs can be regarded as educational tools that improve social contact between teachers and learners, even outside the physical schooling environment. A learner might, for instance, scan their textbooks and only take home a smartphone containing the digital pages. Learners will have a lighter load, their data retrieval rate will be higher, and fewer lost or damaged textbooks will be reported. Thus, BYOD initiatives will help learners achieve their educational goals and allow them to acquire skills such as working smartly, irrespective of their geographical location. They will be guaranteed the freedom and flexibility to learn, known as 'anywhere-anytime teaching', promoting access for teachers to diverse student populations from diverse backgrounds [12]. In this scenario, geography learners will not be restricted by the availability of either textbooks or libraries since they can access online learning materials readily available and retrievable at the touch of a button on their MSPs.

In the research of Voilioti et al. [2]; France, Lee, MacLachan, and McPhee [8] it was asserted that most learners now own more powerful MSPs and have better connectivity than traditional desktop computers (see Figure 3).

Figure 3. Components of VR. Source: adapted from [2].

To keep abreast of developments in the field, geography teachers must grasp the opportunity and upload software that will benefit their learners onto the latter's gadgets to ensure that learners use their MSPs optimally for academic purposes. MSPs are affordable, portable, and multi-functional, allowing learners to control their learning [3,13]. MSPs are compatible with various devices previously regarded as key to phasing in digital education in schools. Thus, they offer the potential to fast-track their integration into teaching geography. This creates an opportunity to alter any environment to serve as a learning space, thanks to the portability and flexibility of MSPs.

According to France et al. [13], the COVID-19 pandemic and the introduction of smartphones brought wholesale changes to the educational space, bringing the challenges of volatility, uncertainty, complexity, and ambiguity (VUCA) to everyday life. Given the rise in mobile technologies, most universities must accommodate dual teaching modes: residential and online. A blended approach accommodates students seeking university degrees without attending on-campus lectures. The same goes for schools, where home- and residence-based schooling can be accommodated. These learning modes are made possible by introducing MSPs in the learning space. For this scenario to be realistic, however, drastic changes, greater creativity, and some innovations are required in both basic and higher education institutions [12]. The benefit of such an exercise is the creation of life-long learners equipped with the 4IR skills that have become imperative in the workplace. Education will, out of necessity, become personalized to meet individual learner needs. MSP implementation, therefore, calls for a paradigm shift not only in terms of pedagogy, but also in assessment and assessment monitoring techniques [13]. By contrast, France et al. [13] point out that it is unfortunate that some students will use mobile devices to cheat during assessments, which defeats the purpose of using MSPs in the learning context [7].

Many teachers download educational materials using the facilities at a local teacher centre locally. Such centres are in districts, but there are also provincial teacher development institutes. The establishment of district education centres in South Africa represents an attempt by the government to bridge the rural–urban digital divide in terms of ICT provision and user access to resources [2,6,14]. Recent studies revealed that it is incredibly challenging in a normal classroom setting to integrate ICTs effectively since many schools allocate (at most) one hour a day to lesson presentations and assessments [15,16]. Most schools are overcrowded, especially in the townships and rural areas. That means teachers fail to work one-on-one with their learners, often seeing struggling learners lagging unassisted. To exacerbate matters, it becomes difficult for a learner who misses completing homework tasks independently [6,15–17].

Teachers now have a golden opportunity to capacitate individual geography learners with digital device-operating skills to ensure order and discipline in class. Every learner must be engaged in the learning experience, learn by using their device, and learn at their own pace. If that happens, teachers will have more leeway to pay individual attention to slower learners while accelerating the learning of highflyers by giving them enrichment exercises and differentiating their teaching approaches. Acknowledging individual capacity will boost learners' morale, lower failure rates, and potentially reduce learner dropout rates.

2.3. Theoretical Framework

This article is underpinned by the Professional Development Framework for Digital Learning (PDFDL) [18], which sets the following standards for novice teachers (all of which are also applicable to geography teachers):

- Sound knowledge of the subject;
- Customization of teaching pedagogies to meet learner needs;
- I am mastering highly developed ICT skills while conversing with the seven roles of a teacher, which include the teacher being a life-long learner, subject specialist, assessor, researcher, interpreter, leader, and communicator.

The PDFDL framework requires any digitally compliant educator to possess the following competencies for ICTs to be effectively integrated into the teaching and learning space. S/he must proceed as follows:

- Be prepared to explore and experiment with ICTs, to enhance their teaching;
- Use digital tools to reflect on the challenges and successes of each lesson;
- Know when to use ICTs to enhance learning;
- Willingly form part of professional learning communities (PLCs);
- Use relevant ICTs to produce documents and present lessons;
- Integrate ICTs in various learning environments;
- Develop learners' skills so that they may be benchmarked at the local and global levels;
- Use technology to facilitate learning that would otherwise have been impossible;
- Use ICTs to assess, monitor and give feedback to learners;
- Inculcate a culture of using ICTs ethically;
- Ensure the buy-in of the province, district, and school by implementing their ICT integration strategies;
- Be a team player who plans for and implements digital learning in the school;
- Be the digital learning champion at the school, earning peer support [18].

The PDFDL is highlighted as an invaluable model in terms of the critical contributions it makes towards improving those educator competencies required for the effective integration of ICTs in the teaching and learning space, especially in the 4IR era. This means teachers need to produce learners who can be benchmarked globally, are not technophobic, and can relate to the curriculum content and align it with their daily activities. Any geography teacher who is not sufficiently capacitated to deal with learners who are digital natives (i.e., thoroughly at home in the digital world) and who do not see the value in using mobile technologies to transmit challenging concepts will find it extremely difficult to manage classes that are taught via digitally mediated lessons [18].

Also worth discussing is the impact ICT integration theory might have in capacitating serving and pre-service teachers as their teaching skills are honed and finessed and their subject knowledge expanded.

In summary, the following research gap has been identified: despite the flexibility of the MSPs for geography learning and teaching, schools still miss the opportunities such devices bring to the educational landscape.

This study aims to fill the gap and provide answers to the following questions:

(1) How can MSPs be used to learn and teach geography in South African schools?
(2) What are the reasons for a paradigm shift towards adopting MSPs as critical tools for geography learning and teaching?

3. Materials and Methods

3.1. Research Approach

The following qualitative methodological steps were taken: Semi-structured interviews were conducted to understand the lived experiences of how MSPs facilitate the learning and teaching of geography. In addition, documents were reviewed to ascertain whether school policies allow using MSPs for learning and teaching geography. Finally, formal and informal observations were made to verify the responses made by participants during the interviewing stages. According to [19], the qualitative approach requires researchers to dig deep to arrive at an in-depth understanding of the phenomenon under study; in this case, whether the study participants viewed MSPs as key in teaching FET-phase geography in South African schools. Since qualitative research accommodates and reflects the participants' voices concerning how they view reality, this study relied on that approach to garner their perspectives on why they perceive mobile phones as indispensable in their contexts when seeking to integrate technology into their geography teaching [19]. The researchers employed case studies in this article. According to Starman [20], case studies allow researchers to understand concepts in depth through the lens of participants in their contexts. The data collected were analyzed into themes. Furthermore, researchers employed the document review to triangulate the data collected via interviews and observations.

3.2. Research Design

As Starman [20] points out, a significant body of knowledge in disciplines such as Medicine, Psychology, History, and Education is generated by case studies. A case study is a strategy used to research a specific phenomenon within its context, using various sources of evidence [21–23]. Furthermore, Starman [20] defines a case study as a thorough, detailed, and meticulous description of an individual case; the variables in a specific context may vary significantly from other cases at different sites.

In this article, the researchers used a case study research design to collect data from the participants and thoroughly understand the experiences they encountered in their settings. Further, a case study was deemed the ideal tool for answering why the study participants perceived MSPs as an integral component of their teaching practice.

3.3. Data-Collection Instruments

In the larger study, interviews, observation, and document analysis were used as data collection instruments, in keeping with the recommendations of [19].

3.3.1. Interviews

A research interview is a discussion during which the researcher seeks to collect descriptions of an interviewee's real-life world, as per their observations and interpretations thereof, and the meanings s/he attaches to the phenomenon under study [21,23]. For a phenomenon to be correctly described, interviewers may rely on an array of techniques, including face-to-face sessions, telephonic and internet-related platforms (WhatsApp video calls or Teams calls), email messages, mobile software management (MSM) or voice notes, (VNs) or social media platforms such as Facebook and Twitter [21,22].

The researchers interviewed 31 participants: 13 teachers, 10 learners, and 8 parents. The interviews lasted for fifteen minutes each.

3.3.2. Formal Observation

In this study, the researchers conducted 13 formal and 4 informal observations. At that point, they acted as non-participant observers, an approach that allowed them to observe first-hand how the participating teachers integrated MSPs in their geography classrooms. The interactions between the teachers and learners were also observed to determine their use of and responses to MSPs as teaching and learning tools.

3.3.3. Document Review

Reviewing documents such as the use of MSPs at school and the minutes of the meetings regarding MSP usage helped the researchers to triangulate the data obtained from the participants to ascertain the validity, reliability, and credibility of the findings.

3.4. Ethical Compliance

Researchers obtained written consent from all the parties concerned before commencing the study. The researchers sought and received permission from the provincial Department of Education in KwaZulu-Natal to access the research sites. Participants were alerted that they had the right to withdraw participation at any study stage.

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4. Results

To answer the first question—How can MSPs be used to facilitate learning and teaching geography in South African schools? —geography teachers, learners, and parents whose children were taking geography courses were purposively sampled. The results show that the use of MSPs in teaching geography, irrespective of ICT applications (apps), was well accepted by all the participants in all categories. This is indicated by the high percentage of ICT app usage (see Table 1). In addition to that, there is a need to capacitate all categories of respondents on how the Sketch It app can benefit them (see Table 1). From the results, we can see that MSPs are considered the missing link towards improving the teaching and learning of geography (refer to Table 1). Compared to teachers and parents, learners tend to be more comfortable using MSPs in their geography learning (refer to Table 1).

To answer the second question—is there a need for a paradigm shift towards adopting MSPs in the learning and teaching of geography? —we looked at the utterances made by participants on the benefits they enjoyed in embracing MSPs in the learning and teaching of geography. The results revealed that MSPs have the potential to improve parental involvement in the teaching of geography. This is indicated by parents who have embraced using online platforms, such as WhatsApp, Global Positioning System (GPS), and Google Earth, to support their children's education (see table). However, parents must be encouraged to use other relevant apps like Sketch It (see Table 1).

Table 1. The results of MSPs' use in the teaching of geography.

ICT Application	Number of Users	Percentage	Benefits of Using the Application
YouTube Videos	08 learners	80%	Watching videos to simplify abstract concepts
	11 teachers	85%	Downloading videos for lesson presentation
	06 parents	75%	Watching videos to assist children with homework
WhatsApp Portal	10 learners	100%	Communicate with teachers
	13 teachers	100%	Upload activities and support material to learners
	08 parents	100%	Receive and submit activities to teachers
Digital Cameras	10 learners	100%	Capture high-resolution images for our projects
	13 teachers	100%	Capture images to facilitate content taught to learners
	06 parents	75%	Able to zoom into images of activities sent via online platforms
Google Earth	09 learners	90%	Able to view three-dimensional images
	11 teachers	85%	Able to capacitate learners on how to measure distances on digital maps
	06 parents	75%	Able to view different locations and features needed for school activities

Table 1. *Cont.*

ICT Application	Number of Users	Percentage	Benefits of Using the Application
Writer Plus	10 learners	100%	Use Writer Plus to write the notes
	12 teachers	92%	Able to write critical items that are needed for lesson presentations
	00 parents	0%	Education is needed in this aspect
Sketch It	07 learners	70%	It enables me to draw simple sketches on my device
	08 teachers	62%	Assist in sketching customized diagrams
	02 parents	25%	Helps to draw rough sketches of images downloaded from online platforms
GPS/Navigator	10 learners	100%	Helps to locate places in real time
	13 teachers	100%	Assist in finding places
	08 parents	100%	Handy in ensuring that parents are well-positioned to assist children with homework

Source: adapted from participants' utterances.

5. Discussion of Findings

In seeking to examine whether MSPs are key in integrating ICTs in the teaching of geography, the discussions of the findings of this study are presented under the following themes:

- MSPs, as a teaching tool, contribute to teamwork;
- MSPs improve learner interest in geography;
- MSPs promote virtual learning in geography.

5.1. MSPs, as a Teaching Tool, Contribute to Teamwork

MSPs can yield positive results in the teaching and learning space in 21st-century classrooms by helping learners think critically, encouraging a culture of life-long learning, and teaching social responsibility to them from an early age. MSP integration in teaching ensures that teamwork emerges, as learners invariably begin to assist one another during the learning process. During geography lessons, for instance, learners may also be given appropriate tasks and checklists which enable them to work autonomously, thus granting the teacher an opportunity to help those struggling learners. Digital learning through YouTube videos may solve many obstacles in teaching geography [24–26]. These findings align with the PDFDL recommendations, which call on teachers to master highly developed ICT skills and aspire to be life-long learners [17]. As one geography learner participant indicated:

> [ICT integration in the teaching of geography] during the hard lockdown assisted me in many ways, such as not being asked by my teachers to submit group activities. Such activities are problematic in the sense that we work as a team. We are forced to wait for other learners to contribute to data collection, analysis of the data presented, and compilation of the whole project for submission. [. . .] I managed to use my smartphone to research using [. . .] online platforms such as Google and the Wi-Fi router from my mother. These gadgets enabled me to do a lot of work quickly.]

From the above comment, it appeared that as an MSP, technology enabled this geography learner participant to complete challenging tasks without face-to-face teaching during the COVID-19 pandemic. S/he highlighted how working alone at their own pace helped them overcome the difficulties of working as a team. This comment confirms that participants can save time by relying on ICTs to teach and learn geography. If downloaded on their mobile phones, Google Maps and Navigator can, for instance, help learners to determine spatial locations [27,28]. Teachers, learners, and parents can use different technologies and platforms in times of uncertainty since they offer a solution to many education-related problems (a lack of internet connectivity, the different rates at which learners learn, enriched materials for high achievers) [24,26,29]. This attribute proved to be effective during the hard lockdown, as all stakeholders had to rethink their approaches to teaching and learning to avoid having the 2020 academic year scrapped, a possibility which the MEC (Panyaza Lesufi) of the Gauteng Department of Education was loath to entertain. He urged school leaders to find ways to equip learners in a way that would make them more resilient and learning more equitable. One recommendation was that the WhatsApp portal be repurposed by forming teaching and learning groups. First, teachers received and shared COVID-19-related information and teaching materials, which they had to share with learner groups via MSPs [24,26]. Had it not been for technology integration, such as using MSPs, the proposed move to start the academic year afresh would not have materialized. The above findings support the notion that geography teachers not only need to have a sound knowledge of their subject but also need to focus on self-development by working as a team (during the pandemic turmoil, by generating model lessons for their colleagues to use and receiving related input from them), thereby showing their mastery of technology-related skills, as per the PDFDL model postulated by [18].

5.2. MSPs Improve Learner Interest in Geography

According to Bikar, Rathakrisham, Rabe, Mahat, Sharif, and Talin [27], ICT integration in geography using geographic information systems (GIS) is affirmed as a tool in teaching and learning map skills that can improve learner performance and outcomes more than traditional methods can. Furthermore, technology integration in STEM (Science, Technology, Engineering, and Mathematics) subjects is gaining momentum. Still, excluding such technologies from teaching makes it difficult for geography learners (amongst others) to develop an interest in that subject since it is predominantly taught using conventional pedagogies [27,28]. In addition, Bikar et al. [27] concede that little attention has been paid to how the uptake and implementation of ICTs may help strengthen learners' skills—for instance, by using educational games uploaded onto their mobile devices [27,29–31].

If Quantum GIS 3.16 software is uploaded onto MSPs to teach map skills, it can strengthen and improve learners' motivation to learn and help poorly performing learners develop the requisite skills at their own pace. Geography teachers may encourage learners to collect data using their MSPs before going to an internet café or the computer room, putting their research projects together, or submitting their research tasks online from their mobiles [27].

While completing projects, learners' social skills will improve, and they will learn to work together (collaborative learning) by taking pictures on their mobile phones during fieldwork. Teachers can upload notes with diagrams to facilitate learners' understanding on the geography WhatsApp platform so that learners who experience barriers to learning (e.g., the visually impaired) may be assisted by magnifying their learning material (zooming in and out), thus making their learning experience more exciting and accessible. This will encourage geography learners to enjoy using their mobile devices for educational purposes. Teachers should urge learners to 'play' with their phones constructively to familiarize them with their usage.

In the voice of Abraham and Fanny [28], caution is made that even though learners might be adept at handling a range of gadgets across multiple platforms, teachers need to be trained to use social media (e.g., WhatsApp or instant messaging) if such tools are to be used to facilitate teaching [28]. This was confirmed by a geography learner participant, who indicated the following:

> [During the hard lockdown, I spent three months away from school, but with the introduction of WhatsApp learning in geography teaching, I managed to cover all the work that our teachers wanted us to do for the year. Without it [ICT integration in learning geography], our 2020 academic year would be wasted. Our teachers managed to send us activities to our smartphones, which we managed to submit within a specified time. They even ensured that we accessed the remedial

> work for our submitted activities. Our teachers used WhatsApp and emails to assist us with geography lessons.]

The above learner participant valued the integration of MSPs and related ICTs in the educational space to allow learners to thrive under the uncertain learning conditions brought on by the COVID-19 pandemic. The PDFDL framework calls on teachers to explore and experiment with ICTs to enhance their teaching practice before they can qualify to be regarded as digitally compliant and capable of helping a new generation of young learners who are digital natives and, thus, highly comfortable with a variety of electronic devices [18]. As the above utterance confirms, the teacher employed two means of communicating with their learners and making remedial exercises/tasks available to optimize their learning opportunities.

5.3. MSPs Promote Virtual Reality in Geography

Google Earth is a geo-visualization ICT tool that allows geographers to zoom in and out of the virtual globe. It grants them access to digital images that cannot be captured in textbooks (which are relatively inflexible resources) [24,27]. Similarly, France et al. [12] concur that MSPs can record, transfer, or provide information to end-users in any given location if the user has sufficient mobile data. In addition, he asserts that MSPs help teach learners new content since they promote cooperative learning. The geography teacher might, for instance, use Google Earth to demonstrate to a few learners how to measure a distance on the MSP using this app [6,12].

From there, those learners could show their classmates how it is done on their digital devices, allowing teachers to individualize their teaching. This happens when digital content is displayed and highflyers work independently, leaving the stragglers to alert the teacher that they require assistance. Furthermore, Lo [30] explains that schools in Japan use ICTs to facilitate geography teaching using the problem-based approach [6,27].

GIS is an enabler, as it allows learners to access data from myriad sources that they can analyze, manipulate, and integrate, such that they can identify patterns and relationships between phenomena in different places, locally and globally [28]. This can be illustrated by a learner watching a video (on their MSP) showing a tropical cyclone, where relationships between high temperatures in coastal areas act as a source of energy for such a weather phenomenon to develop while making landfall slowly, causing it to dissipate. Geography learners will thus appreciate the importance of satellite images in ensuring that real-time information is available to weather forecasters and communities so that timeous evacuation plans may be effected if needed.

Using satellite images indicates the importance of integrating virtual learning in teaching geography, a much more colourful and exciting approach than the old talk-and-chalk method. As one geography learner participant indicated:

> [Online geography learning turned out to be the missing link as a supporting tool for my studies. I used digital gadgets to access visual images of what my geography teachers taught me in class. [It] allowed me to be alone and do things individually before I could ask for help from my teacher. There are times when I manage [d] to [gain a] better understanding of concepts from my [mobile] since such concepts [showed] colour and dimensions that would have given my Geography teacher [. . .] difficult times when asked to present the concept in question. Before the hard lockdown, I used to fail to submit tasks to my teachers and they [were] not [. . .] in a position to reprimand me [for] doing that. Now that there are smartphones that can even send emails, my parents [. . .] check [on] the progress of my studies by communicating directly with my subject teachers instead of asking me.]

This learner participant valued the contribution MSPs brought to their personal learning experience, providing individual attention (also from their parents) and enabling them to assess their strengths and weaknesses in growing as a digital citizen.

In the Japanese context, learners must work in groups to view different parts of the world, noting similarities and differences, as [29] reported. To do so, teachers in Japan have had to upskill their learners' online searching abilities [10]. This is performed by geography teachers asking learners to draw geographical features such as mesas and buttes in class by using applications (apps) such as Sketchbook Pro 9.1, which can be uploaded onto an MSP. Through active learning, learners can produce their learning material rather than receive ready-made content or learn passively as mere recipients of information. A study by [28] found that introducing artificial intelligence (AI) in ChatGPT4.0 has revolutionized teaching. The fact that this app can respond to questions poses a threat in that learners may use their MSPs to cheat during online assessment activities in instances where tests or assignments are uploaded onto their devices [30,31].

This innovation may negatively affect independent learning since many feel learners will no longer need teachers to mediate content if the material can be accessed at the touch of a button. Teachers must ensure that content is appealingly presented via various digital platforms, using tools such as tablets, laptops, cell phones, interactive whiteboards, and document cameras, to mention a few [17]. Working in groups, geography learners might, for instance, use GE to identify highly topical areas in the media space. While doing so, they may be assessed on their ability to work together and communicate extensively on their chosen topic.

The geography teacher might upload a YouTube video on tropical cyclones to the class's WhatsApp group, which learners at home can view. They then must complete a worksheet, after which their responses are discussed in class. This will ensure the learners gain virtual experience and focus on distant places without physically going to such areas. The recommendation by [28] is that GE be used to expose geography learners to PBL (problem-based learning), with the teacher inviting learners to seek solutions to the manifold issues troubling people in different parts of the world by brainstorming ideas [27].

The 4IR has allowed teachers and learners to use MSPs to facilitate lesson delivery. As one geography learner participant indicated:

> [Online learning enabled me to create a safe space to study without the fear of being mocked by my classmates each time I [. . .] answered Geography questions my teacher posed incorrectly. This kind of behaviour ended [up] affecting me negatively, to such an extent that I did not ask my teacher any clarity-seeking questions in class. With the arrival of the hard lockdown, I had no alternative but to learn a new skill of asking teachers questions [from] the comfort of my home. In short, through ICT, I managed to use my home as an alternative space for learning how to use Google Maps to find directions and develop [ed] a culture of self-discipline, such that I continue learning even in the absence of my teachers.]

The above statement highlights the importance of technology integration in revealing learners' untapped talents and innovation. Without COVID-19, learners could not dig deep and reveal some innovative skills needed in the 21st century to prepare them to become digital citizens. Apps uploaded on MSPs (e.g., YouTube videos and virtual reality images) can help geography learners better understand mapwork concepts such as 3D when features such as plateaus are identified using Google Earth [12].

Worryingly, the study conducted by [1] confirms that many schools continue to ban mobile phones on the premises, even for curriculum-based purposes. This practice, according to [1], appeals for technology akin to that of "a forbidden fruit". In the present study, the researchers' classroom observations corroborated a shortage of textbooks in the schools under study [1]. In many instances, that left teachers with no other option but to breach the policy on the use of mobile phones. Some participants indicated that they allowed their geography learners to use MSPs in class on the condition that the devices were kept in flight mode.

Besides the enormous benefits that MSPs bring to the teaching of geography, educators are aware of the challenges presented by cyberbullying and the digital divide, as well as the sense of exclusion that arises when parents cannot afford to purchase smartphones or data for their children. This, then, calls for a review of ICT policies in schools. These findings are confirmed by the parent participant of a geography learner, who indicated the following:

> [I feel that the Department of Basic Education must pass a policy to make ICTs [. . .] compulsory in all schools. This will lighten [. . .] the load on our shoulders, meaning that the government will automatically finance its implementation. This is because not all learners are privileged enough to own digital gadgets, let alone to maintain them. The hard lockdown has put a lot of pressure on us, as parents, because we were forced to try to purchase such gadgets, even if it meant we go to bed on [an] empty stomach. Other geography teachers prefer to get their submissions done via email, and that makes my life difficult, as there is no laptop or [. . .] smartphone at home, let alone the money for buying [. . .] data bundles. This makes me feel I am not part of the 'new normal' [post-COVID]. Such challenges make us [. . .] feel as if we are just spectators instead of adding value to the education of our children.]

This parent participant highlighted the challenges faced by poor communities that are expected to become digital citizens without the ways and means to do so. It would be imperative to consider the socioeconomic conditions of communities, which might require the DBE to phase in technology-based assistance in local schools gradually. In addition, policies must align with any of the government's plans to prepare teachers and learners for technology-mediated education. The need to review policies on the use of MSPs to promote virtual learning in geography teaching is affirmed by the comments made by a geography teacher participant, who indicated the following:

> [I find it challenging to ensure that learners strictly follow [. . .] ICT integration during my lessons. Our ICT policy at school indicates [s] that learners will only use their mobile gadgets under the supervision of teachers and that learner gadgets should be in [. . .] plane mode. Surprisingly, I get disturbed by learners' mobile phones that ring in class during lessons. This leads to unnecessary disciplinary measures [being] taken against such a child. From there, the time that should have been used for teaching is spent dealing with [. . .] disciplinary issues that add no value to the school's curriculum.]

This teacher participant highlighted the challenges s/he faces each time MSPs are used in class to promote virtual reality learning. In this case, the teacher meets the competencies set out by the PDFDL, which requires every teacher to be a life-long learner, yet learners make it challenging for such a teacher to gauge the efficacy of MSPs in their geography lesson [18]. The documents in the form of minutes of the meetings held by various stakeholders at research schools revealed that there were contradicting views in terms of allowing the use of MSPs in schools. It was shown that some stakeholders favour using ICTs, while the majority were totally against it.

Surprisingly, from the researchers' observations, some stakeholders, in the form of learners and teachers, continued to contradict the policies and resolutions on using MSPs, as they indicated the flexibility and convenience such devices bring to access real-time solutions.

6. Projections of This Study

We projected that all the geography teachers have fully embraced the power of ICTs in their teaching. Our study also projected that schools have adequate devices to integrate technology. Surprisingly, schools have crafted policies that ban the use of MSPs and have a shortage of textbooks. They could have uploaded e-books as an alternative to the shortage of learning materials.

7. Limitations of This Study

The researchers could not avoid the limitations of our research. With the choice of purposive sampling, some participants with possible divergent ideas were left out. This study covered one district in KwaZulu-Natal, meaning that the results of this study cannot be generalized throughout the whole Republic of South Africa.

8. Conclusions

The current investigation focused on why participants viewed the integration of MSPs as disruptive yet highly valuable educational technologies to use in teaching and learning geography as a subject. The research findings revealed that a paradigm shift is called for, requiring teachers and tertiary institutions to rethink their modes of teaching. This is indicated by how participants embrace using MSPs in this study. Since geography is multidisciplinary and deals with current issues, learners, teachers, and parents must become life-long learners and researchers by taking MSPs in their stride. This practice may have a ripple effect on other subjects as well.

Furthermore, the literature reviewed and the theoretical framework underpinning this study support the notion that MSPs are indispensable in facilitating geography learning and teaching. Research results revealed that learners are already enthused about using various devices to learn. The introduction of smartphones as mobile technologies in the educational space, whether in primary, secondary, or tertiary educational settings, has become unavoidable. The results show that MSPs have the potential to increasingly involve parents in the education of their children as they collaborate with their teachers. As the findings revealed, learners in the era of 4IR expect to use multiple devices and platforms to learn, and with distance education becoming a reality, online teaching will become the new normal in this century. This study highlighted the need to involve parents in their children's education, as they use ICTs to assist them with learning activities. This highlights the ability of ICTs to transcend the walls of the classroom and introduce self-regulated learning.

9. Recommendations

Teacher self-development: geography teachers need to upskill themselves to deal with the inescapable reality of adopting MSPs in their teaching.

Conscientizing learners: learners, for their part, will have to be conscientious to focus on learning on or with their MSPs rather than merely using them for entertainment.

Tighter classroom controls: schools must implement stricter classroom controls to ensure learners do not display unbecoming behaviors' during learning processes.

Reviewing existing policies: various stakeholders may need to review existing policies on using MSPs to accommodate the new normal in the teaching and learning space.

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education sciences

Article

E-Textbooks as a Teaching Aid at a University of Technology in South Africa: A Cultural-Historical Activity Theory Analysis

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Abstract: The past two years saw a rapid proliferation of information and communication technologies (ICTs) in higher education. Digital technologies and environments offer many affordances. New digital literacy practices in universities have implications for teaching and learning. E-textbooks, in particular, act as mediating tools that can facilitate teaching and learning through developing students' understandings of scientific concepts. This paper positions e-textbooks as mediators of learning, rather than merely objects of learning. There is thus a need to understand the mediating role of e-textbooks that lecturers draw on in their teaching. While much research was conducted on students' use of e-textbooks, relatively little was conducted on lecturers' use of e-textbooks in engineering education. The current study aimed to answer the following research question*: What are lecturers' perspectives on the use of e-textbooks to facilitate learning in engineering?* To address this question, data were collected through five individual interviews conducted with engineering lecturers working in the Extended Curriculum Programme (ECP) of first-year students from three engineering departments (chemical engineering, mechanical engineering, and nautical science) at a university of technology in South Africa. The data were analysed using thematic content analysis with the help of ATLAS.ti. Data analysis was guided by a theoretical framework that drew on the cultural-historical activity theory (CHAT). In this study, the focus was on e-textbooks as pedagogical tools within engineering teaching and learning. The findings provide insight into how lecturers incorporate e-textbooks into their teaching, but also reveal the extent to which new digital literacy reading practices remain unfamiliar to engineering lecturers. CHAT enabled the identification of a critical insight, namely, the tension between mediation and division of labour. This highlights important aspects of the discourse surrounding seamless technology integration in higher education. The discussion points to the need for an expansive transformation regarding the use of e-textbooks as important mediating tools for teaching and learning.

Keywords: mediating tools; cultural-historical activity theory; physics e-textbooks; digital literacy; engagement strategies; teaching and learning in higher education

1. Introduction

In South Africa, traditional and comprehensive universities in higher education were able to adjust relatively swiftly to these new demands. However, universities of technology (UoTs) faced substantial challenges, which underscored existing inequalities in access to and participation in higher education [1]. In response to the pandemic, South African Higher Education Minister, Blade Nzimande, announced in March 2020 that all universities would move to remote online or distance learning to save the academic year [2]. Following this directive, the executive management of universities across the country advised educators to prepare for fully remote learning, utilising various modes of knowledge transfer, including video, audio, and interactive reading texts.

Engineering lecturers at South African higher education institutions (HEIs) encountered significant challenges during this transition, particularly in adapting their course content to online formats and in devising strategies to accommodate a diverse student body. South Africa's higher education landscape comprises three distinct types of universities:

traditional universities, comprehensive universities, and UoTs. The UoTs, which evolved from institutions akin to technical colleges and were formerly known as technikons, do not typically enjoy the same research-intensive status as their traditional counterparts. These institutions were originally established to provide vocational education and often hired faculty with technical expertise from professional sectors rather than those with advanced, research-oriented degrees [3].

The majority of students at UoTs come from marginalised communities and previously disadvantaged backgrounds, with limited resources. During the pandemic, particularly in November 2020, these students had to rely heavily on digital resources, such as e-textbooks, for all their engineering subjects. With no access to university libraries and the acquisition of physical textbooks from global online platforms, such as Amazon, being time-consuming, the shift from paper textbooks to digital e-textbooks became inevitable.

Furthermore, the transition to technology-enhanced learning in South Africa posed unique challenges, especially for first-year engineering students, many of whom come from rural areas with limited access to technology. A significant portion of these students encountered computers for the first time upon entering tertiary education. The COVID-19 pandemic accelerated the adoption of online learning across all South African universities, revealing the advantages of digital resources, such as e-textbooks, particularly in terms of affordability and accessibility. However, the transition was not seamless for all educators. Lecturers accustomed to face-to-face teaching often struggled with the digital shift, facing the daunting task of converting traditional lectures into online formats. Conversely, those with prior experience in technology-integrated teaching recognised the potential of online platforms to enhance educational opportunities. This study investigated lecturers' practices regarding the use of e-textbooks to understand whether and how these digital resources transformed teaching practices.

2. Literature Review

E-textbooks were adopted by universities as digital equivalents of physical books, offering additional interactive functionalities that enhance the learning experience [4]. Unlike traditional digital reading, e-textbooks promote adaptive and self-regulated learning for students [5,6]. This section explores the various aspects of e-textbook use and interactivity.

Despite extensive literature, there is no universally accepted definition of an e-textbook, with definitions varying depending on context and usage. Some explanations liken e-books to "paper behind the screen" [7–10], which does not differentiate them from other digital formats, such as PDFs [10–12]. E-books are generally defined as digital texts accessed via electronic devices such as e-readers, personal digital assistants (PDAs), or mobile phones [3,13].

Understanding the distinction between e-textbooks, e-books, and PDFs is crucial. The literature offers various names for academic reading, but e-textbooks stand out due to their degree of interactivity, which significantly influences how students interact with the text [14–16]. Definitions of e-textbooks often include the integration of workbooks, reference books, exercise books, casebooks, and instruction manuals [6]. Many publishers now offer interactive e-textbooks designed to meet curricular standards, featuring static hypertext or multimodal text connected to the internet and hosted on educational platforms [6].

Interactive e-textbooks have the potential to enhance learning outcomes through the tools they provide [14]. These e-textbooks can be classified as either "page-fidelity e-textbooks", which replicate the static layout of physical books, or "reflowable e-textbooks", which include multimedia and self-testing features [17]. These interactive functions can significantly impact student engagement, though the cost of engineering e-textbooks, ranging between R800 and R1500, can be a barrier depending on the publisher and the interactive platform used.

While interactive e-textbooks offer more features to engage students, their adoption is not guaranteed [18]. Studies indicate mixed student preferences between e-textbooks and physical textbooks [19]. Some students prefer e-textbooks [20,21], while others favour physical textbooks [22], often due to factors such as cost and familiarity. Although traditional textbooks are generally more expensive, the perceived usefulness and satisfaction of learning with e-textbooks play a crucial role in their continued adoption [23–28].

Martin-Beltrán, Tigert, Peercy and Silverman [29] found that students were more likely to re-read and use text features for comprehension with digital texts, suggesting that traditional texts might better support literacy development. Martin-Beltrán et al.'s [29] findings highlight the importance of well-designed text features in both digital and traditional formats and the need for educators to guide students in using these features effectively.

However, introducing a new tool, such as interactive e-textbooks, does not guarantee a smooth transition from face-to-face to online learning, especially for students unfamiliar with digital learning environments [14,23,30]. While these e-textbooks offer various tools to support student learning, their success depends on factors such as student engagement and interest in the subject matter [31].

The e-textbooks, whether digital or physical, provide a structured framework that helps learners follow a systematic syllabus and progress through their courses. They reduce the time and effort required by teachers to prepare course materials, while also enabling students to study at their own pace, thereby fostering autonomy and independence [11,32,33]. The integration of e-textbooks into higher education offers significant potential, but their effectiveness depends on thoughtful implementation and the willingness of both educators and students to adapt to new learning tools [34].

3. Theoretical Framework

This study used cultural-historical activity theory (CHAT), originally proposed by the Russian socio-cognitive theorists, Vygotsky [35] and Leont'ev [36], and further developed by Engeström [37,38], as a guiding framework. CHAT alerts us to the relationship between subjects and the objects of their activities, the role of tools, mediation, and the context of the activity [37]. Specifically, CHAT understands that human activity is always undertaken by subjects, mediated by cultural tools, and embedded within a social context. These interactions are known as the "activity system" [37]. One way to understand the full "activity system" of transformation of the activity system is via the ZPD.

Vygotsky's [37] concept of the ZPD was introduced as a critique of psychometric-based testing in Russian schools, which only assessed learners' current level of achievement, neglecting their potential for future development. The ZPD highlights the potential for emerging behaviour and the "future of development" [37,38]. In this particular study, the focus was on e-textbooks as tools in an engineering teaching and learning system. In the sections that follow, more detail on the theoretical framework used to guide the study, and the theoretical and methodological advantages that CHAT brought to the study, will be discussed.

The first principle of the activity in CHAT is that the object drives the activity [38]. "CHAT views activity in an activity system as the collective, object-orientated, tool-mediated actions of a group as influenced by culture, history, and economics" [39]. CHAT distinguishes between the object and the outcome of a system (see Figure 1). The object is what the subjects understand as the purpose or intention of the activity; it "propels them forward to take action" [40]. In a teaching and learning activity system, we should, firstly, identify the object. In this study, the object was promoting the acquisition of engineering knowledge, more specifically, that which is contained in engineering e-textbooks.

Secondly, we should identify people who are participating in the system. In this case, it can be any educational activity system in which the subjects are engineering lecturers whose purpose (or object) is to teach [41] (see Figure 1). More specifically, the other subjects are students who are in a process of understanding the engineering knowledge that is contained within e-textbooks. The subject acts on an object in order to transform it, using a socio-cultural tool to reach the desired outcome in the activity system.

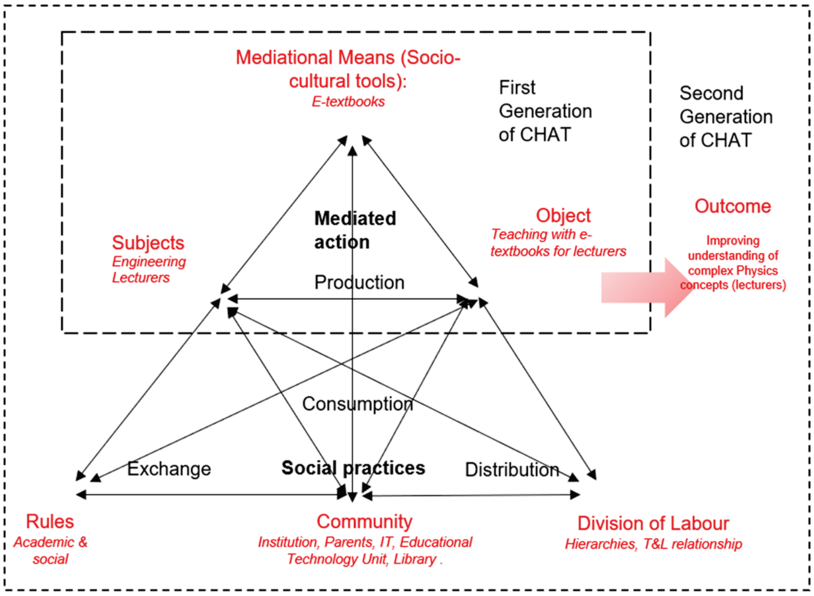


Figure 1. Second generation CHAT: a teaching and learning activity system [37].

The focus of this study was e-textbooks that are understood as socio-cultural tools in support of the object of knowledge acquisition. Within this system, there are other socio-material and cultural mediational tools, such as curricula, facilities, equipment, internet-based and library-based resources and a learning management system (LMS), among others, that are also directed at the object. In order to work successfully on this object, human and other resources are needed—and these may or may not be sufficient for the attainment of the object [42]. This is because university teachers and students work as part of a much broader system that is embedded in an institutional culture that has rules and hierarchies of decision making (or rules and divisions of labour, respectively).

The outcome is the result of the focus on the object. In CHAT, it is important not to conflate the object and the outcome, as an effective activity system must be driven by the object and not the outcome [43]. Thus, the outcome flows from the activity as a whole. In this study, the outcome was promoting students' academic success in engineering. According to CHAT, the outcomes can only be attained if the participants do not lose sight of the object. These objects or tools in an activity system can be human, physical, cultural, or conceptual.

CHAT also points to the socio-cultural-economic context in which the activity occurs. Activity systems are bound by rules. The rules and divisions of labour may enhance or inhibit the students' and teachers' ability to work towards the acquisition of engineering knowledge. The tools and resources need to be available, and appropriate rules and divisions of labour should guide the system (e.g., which tasks are appropriate for students, and which are more appropriate for teachers in achieving the object). In addition, all activity systems include a division of labour, that is, different subjects and human mediators, in their focus on the object, will play different roles and may have different levels of status in a social hierarchy.

The community of an activity system comprises those who are affected by the systems (e.g., parents, professional bodies, employers, etc.), but who are not directly involved in the work of achieving the object [44]. For example, there is a community beyond the subjects that are affected by the activity system that offers support to it, or benefits from the activity. The community can be beneficiaries of the activity, but also stakeholders in the activity. In the case of this study, important community participants included the institution's IT department that maintains the LMS and internet connectivity and educational technologists who play a role in staff training in the use of e-textbooks. While the current study had a particular focus, namely, the e-textbooks that are used to achieve the object of learning, the whole activity system, both processes and outcomes, have to be studied [37].

CHAT includes a focus on the historical development of the activity system. South Africa is an economically, culturally, and socially stratified country inhabited by diverse population groups. The country's unique political history created distinct socio-cultural margins. CHAT provides an especially powerful research lens in the South African context, as it takes the historical, cultural, and socio-economic context of the country into consideration when studying engineering education. Practices and conventions in education have "deep roots" [45] and are slow to change to accommodate new objects, subjects, tools, rules, communities, and divisions of labour [46]. CHAT thus warns that the introduction of a new tool, such as an e-textbook, could cause disruptions in the system. Such disruptions are not necessarily negative, as activity systems are not static. In other words, they are consistently changing the ways they operate, the resources and tools they use, and orientating themselves towards different purposes.

CHAT is particularly interested in researching new tools in an educational system, as it focuses on development and change in activity systems, often arising from historically derived tensions in an inefficient system [47]. Indeed, many educational studies in CHAT focus on the introduction of new technologies into teaching and learning systems (see e.g., Hardman [30]). One of the difficulties of introducing new tools into the system is that they can change the object, in fact, they may even become the object. This is known as a "tool object reversal" [48]. In their study, Schuh et al. [14] (p. 306) point out that "e-textbook use can be limited when students act on it merely as an object without any intentional goal". In other words, if the technology is too disruptive or too complex, it becomes the focus of the activity instead of the tool and therefore will not achieve the intended object. By studying the whole system, researchers can identify the interactions that subjects have to negotiate, as well as the tensions and contradictions that are foregrounded when a new tool is introduced.

CHAT is a dialectic theory, and the dialectic concept of "contradiction" plays a crucial part in it. Contradictions make the object a "moving, motivated and future-generating target" [49] (p. 89). Finding contradictions or "sticking points" in an activity system points to ways of improving practices within the system. In an activity system analysis (ASA), these misalignments, contradictions, and other disturbances "hold within them the possibility of the collective propelling themselves forward to search for new ways of doing and achieving 'what is not yet there'" [39] (p. 14).

Finally, CHAT provides a method for researchers to understand and describe the interactions between individuals and the environment in a natural setting [49]. Individual interaction is based on holistic engagement between individuals and their environment. CHAT is an effective unit of analysis in an investigation of how students and lecturers use a new tool, such as e-textbooks, in a learning environment. The purpose of this study was to understand the digital literacy practices of students in order to improve teaching practice. This study used students to identify and understand students' digital literacy practices and determine how these enhance student learning.

4. Method

4.1. Case Study Research Design

A case study is a research design that aims to derive meaning from a specific phenomenon, where related variables cannot be separated from the context [50,51]. The primary objective of a case study is to gain an understanding of a single case rather than comparing multiple cases to draw general conclusions [40]. This research found its methodological foundation in the work of Yamagata-Lynch [40] (pp. 78–79), who argues for the commensurability and established efficacy of case study methodology within the realm of CHAT. Yamagata-Lynch's insights illuminate how case study approaches, with their intrinsic focus on the complexity and contextual richness of specific instances, are uniquely suited to unpacking the nuanced dynamics inherent in CHAT.

Each case study presents a unique narrative, and the expected outcome is to provide specific insights and findings rather than making generalisations [52]. However, in the past, there were divergent opinions regarding the validity and significance of the information obtained from a case study. Today, the role of the case study procedure in engineering education is generally acknowledged. Cohen, Manion, and Morrison [53] believe that the results of case studies could very well be transferable to other phenomena. Case studies are regarded as valuable supplements to other research techniques.

This study employed a case study as a research method because it is well suited to addressing descriptive questions such as "how" and "why" in an empirical investigation that explores a current phenomenon within its real-life setting [51,54]. This study focused on a single case with embedded units, which involved examining multiple units or objects of analysis within that single case.

4.2. Sample for This Study

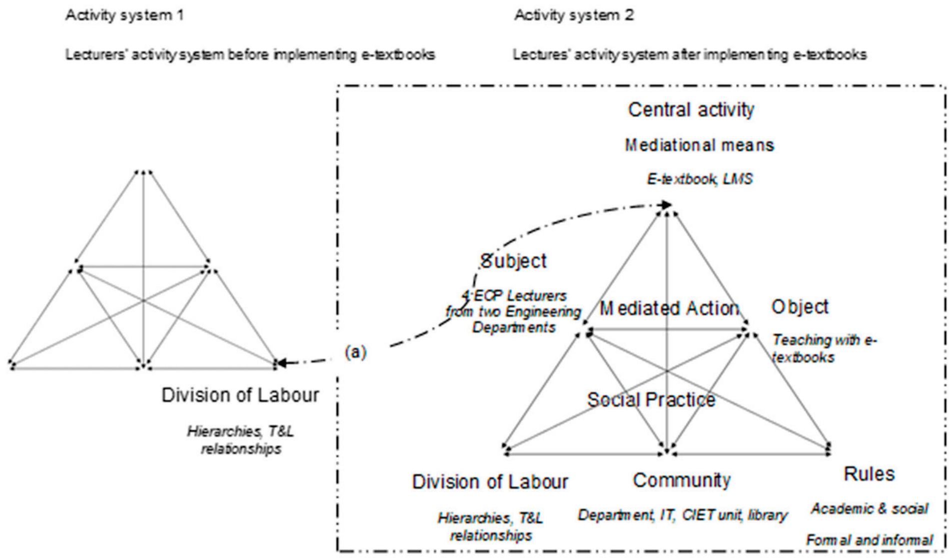
Purposive sampling entails deliberately selecting specific participants or settings based on their potential to provide crucial information that may not be as readily accessible through other methods [50]. For this study, the author selected students and lecturers from the ECP, as these programmes already implemented the use of e-textbooks in the physics subject.

4.3. Data Analysis

During the study, the author took on the role of participant observer by sitting at the back of the computer lab classroom, taking notes on an observation sheet, and managing the audio recorder. The audio recordings were transcribed. The transcriptions consisted of 12 interviews with participants after the reading task which was introduced and used on an e-textbook containing physics for engineers and science students. The excerpts used in this article were analysed using ATLAS.ti software.

Data analysis was conducted using thematic analysis. This inductively and deductively identified themes as they emerged from the interviews in a cyclical process of analysing, coding, validating, and creating themes, which are expressed in different facets of pedagogical practices. The resulting themes were correlated with the literature. The software ATLAS.ti desktop was used for the coding process and the development of themes.

The method of analysis was based on the framework for identifying and analysing contradictions presented by Engeström and Sannino [55]. The analysis was conducted in four steps, which resulted in the identification of four types of contradictions, presented in the discussion section. In the first step, data were reduced by identifying segments significant to the research questions (cf., Jordan and Henderson [56]). These were segments in which the respondents mentioned challenges that teacher leaders discussed in coaching sessions. The second step was analysing each significant segment separately, trying to categorise the section according to the four types of manifestations [55]. Figure 2 shows an example of how the analysis of manifestations was conducted; each significant segment was noted, summarised based on the author's understanding of the quote and its context, and compared to the descriptions of manifestations in order to categorise the section as dilemma, conflict, critical conflict, or double bind. Arguments for the categorisation of manifestation were also noted, and key words for each manifestation were italicised. This resulted in manifestations of contradiction (see Figure 2). In the discussion section, examples are given of the manifestations, aiming to increase the transparency of the results.



Tensions for lecturer participants

Name of contradiction	Type
(a) The role of the lecturer	*Tertiary contradiction:* Mediational Means (activity system 2) and Division of Labour (activity system 1)

Figure 2. A teaching activity system (Source: Engeström [37]).

4.4. Ethics

The ethical application for this research was reviewed and approved by the Ethics Research Committee (ERC) of the Faculty of Engineering and the Built Environment (FEBE) at the University of Cape Town (UCT). Key ethical considerations included obtaining informed consent, ensuring confidentiality, and protecting participants from any potential harm or discomfort.

Informed consent was paramount, with participants fully briefed on the study's aims, their role in it, and their right to withdraw at any point without any repercussions. Privacy and confidentiality were also carefully managed, particularly in classroom settings where group activities may limit individual privacy. To address these concerns, participants' contributions were anonymised and all data were securely stored with access restricted to the research team, ensuring the protection of participants' identities and the integrity of the research process.

5. Discussion

5.1. Data Analysis

Research on the effects of e-learning on the roles of lecturers in digital spaces remains limited [57]. While some studies focus on understanding and accommodating individual responses to change, there is a lack of emphasis on the practical challenges and lived experiences of academics during the transition to digital pedagogy. In contrast to the increasing body of research exploring the student experience in e-learning, where student perspectives are prioritised [58], the voices of lecturers are often overlooked.

As can be seen in Table 1, Lecturers 1, 2, and 3 fulfil multiple roles in their departments. These include not only teaching and research, but also administrative support for the extended curriculum programme in their department. The participants hold the following positions: one is a junior lecturer, one a lecturer, and two are senior lecturers. Before being appointed as lecturers, all participants started their careers at the current university.

Table 1. Lecturer-participant characteristics.

Pseudonym	Role	Rank	Responsibilities	Years of Teaching
Lecturer 1	Lecturing staff and outgoing ECP Coordinator in Chemical Engineering department	Dr, Senior Lecturer	Teaching, administration, managing the ECP programme, research	More than ten years
Lecturer 2	ECP Lecturing staff in Chemical Engineering department	Lecturer	Teaching, administration, support the ECP programme, research	Three years
Lecturer 3	Lecturing staff and newly appointed ECP coordinator in the Chemical Engineering department	Dr, Senior lecturer	Teaching, administration, managing the ECP programme, Teaching and Learning Representative for the department, research	More than ten years
Lecturer 4	ECP lecturing staff in the Department of Maritime Studies, Nautical Science programme	Junior Lecturer	Teaching and studying towards a master's degree	Two years

Within the CHAT framework, the roles of lecturers are understood through the concept of the division of labour, where different members of the academic community engage in various roles with distinct purposes and objectives (mediated action). The division of labour involves the negotiation of responsibilities, tasks, and power dynamics within a classroom setting, whether it be face to face or online, and extends throughout the university structure. In this article, division of labour refers to the manifestation of participants' roles in their teaching. Leont'ev's emphasis on the division of labour underscores its influence on our thought processes as he argues that object-oriented activity is mediated by tools and occurs in specific conditions [47].

As part of the interview, the lecturers discussed their visions and ideas about their own teaching. All the lecturers interviewed claimed to incorporate a significant amount of interactivity into their classrooms. Lecturers 2 and 3 mentioned interactive teaching styles as an example:

> *"I tried to promote an open atmosphere, I want students to interact. So, I tried to keep things a little bit light. … my teaching style is interactive by supporting students with understanding concepts. For example, if a student asks a question that you would consider ridiculous, to some extent, I try not to just say 'yes, it's wrong, or yes, it's right'. I tried to dig a little bit deeper, even if a question was completely wrong, and maybe the whole class could see it. However, I try to dig deeper into where the misconception might have led the students to that conclusion for that type of question just to try and make it seem like it's open for conversation. It's free. They can ask whatever comes to their mind. They can ask, and without feeling too much of a judgement."* [Lecturer 2]

Lecturer 3 also described their teaching style as:

> *"interactive. And I am not somebody that wants to stand in the front of the class and speak the whole time, and when I'm done, I leave."*

However, each lecturer seemed to draw on different philosophies underpinning interaction. For example, Lecturer 4 commented on the idea of facilitation:

> *"The lecturer's role is to facilitate the learning to guide and help a student gain some skills based on specific subjects. Students are coming to the classroom to acquire knowledge and skills for their future fields."*

Lecturer 1 drew on the conversational framework proposed by Laurillard [59] and clickers to improve the participation of the students:

> *"When I started asking myself the question, 'how can my students be active participants in the conversation or dialogue that is happening between the students and me?. . . I adopted the clickers to improve the dialogue in the classroom. So, on the conversational framework, Laurillard also talked about another second phase of it, which is called the interactive side. When you bring in a system, the interactive side becomes more apparent . . . make sure that what you've taught in the classroom now is the reinforcement to test the student's understanding or to gain that level of understanding."*

Lecturer 2 conflated the interactivity with the use of humour:

> *"I try to insert jokes here and there and try to lighten up the mood so that, because I feel like they are learning, it makes it easy for the students to ask and request for clarity on something they don't understand if they feel like the classroom is a safer space. . . . my teaching style of physics as it's kind of an involved subject. So you . . . and there's a lot of content, so you do that, but you can't do that all the time."*

Nonetheless, all four engineering lecturers agreed that lecturing should be interactive and dialogical. Interactive communication between lecturers and students is part of their pedagogical practice. According to Smagorinsky [60] (p. 69), teaching involves mediation, primarily through scaffolding, guidance, and assessment. The terms "scaffolding" and "providing guidance" refer to the use of mediation techniques that involve students in problem-solving activities using cultural tools. In this perspective on teaching, a teacher, who expects students to use tools that are unfamiliar to them for tasks that do not build upon their previous problem-solving experiences, is not truly teaching, but merely assigning and testing. This does not imply that teachers should only ask students to do what they already know, as that would negate the purpose of education. However, it does emphasise the importance of aligning formal instruction with students' prior culturally fostered tool use. When there is little or no congruence between instruction and students' existing knowledge, and when teachers do not establish a reciprocal relationship with students to support appropriate tool use, the instructional process is likely to be ineffective.

The main idea of teaching practice is that to be a successful teacher, a conversation between the lecturer and the students is laid out in a dialogical manner. Vygotsky's concept of the zone of proximal development (ZPD) implies that students need assistance from more capable (or more knowledgeable) others. Such mediation occurs through social interaction. Vygotsky explains the ZPD [61,62] (p. 113) as follows:

> *"The zone of proximal development defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state. These functions could be termed the 'buds' or 'flowers' of development rather than the 'fruits' of development. The actual developmental level characterises mental development retrospectively, while the zone of proximal development characterises mental development prospectively."*

The ZPD is therefore based on the fact that the more knowledgeable one assists the less knowledgeable one. This can be achieved by other students, for example, when working in groups, as Lecturer 3 mentioned:

> *"So, you kind of teach them that you don't only have to think one way . . . you can think outside the box as well. I like group work. So, I'll explain something on the board. And then I'll give them a question. And they can work in groups. I don't mind if they're working in groups because sometimes it's easier when a student explains to another student what they are doing wrong or what they do not understand because they sometimes speak the same language versus me, not the same language thing."*

Many scholars, such as Smagorinsky [60,62] and Hardman [63], agree on the crucial role lectures play in assisting students and mediating in online spaces, even though scholars are still trying to understand how much assistance should be provided to students to make them independent learners and promote self-regulated learning. Sociocultural constructivist views of teaching and learning emphasise the significant agency and active role of learners-as-teachers in the educational process. In constructivist approaches, teachers follow the ZPD concept to move students from an unknown area of knowledge and concepts by using teacher mediation as part of scaffolding tasks.

In comparison with the other lecturers discussed above, Lecturers 2 and 4 described their teaching philosophy as interactive by making the lecturing space informal and "less serious". Setting up rules (whether formal or informal) in the classroom allows these lecturers to promote space for learning by making mistakes. The effect of making informal classroom rules is to promote a student-centred approach, as mentioned by Lecturer 2:

> *"So, I mean, the lecturer can be serious all the time. So, students know that they need to be able to focus on something, when they need to do something, but they can also relax a little bit when time allows."*

Students develop an understanding of engineering concepts in different ways, as Lecturer 2 explained:

> *"Students have different ways of learning; some people are visual people, some are kinesthetics and some are whatever. So, some people learn best with experience, some people learn best by thinking, and some people learn best by just looking. So, for people who are visual, they just want to see the words and whatever.*

Lecturer 2 further related how e-textbooks allow students to learn in these different ways:

> *"E-textbook is the best because the student can actually have all these ways of learning. Depending on the software you have, you can actually have someone reach out the thing for you, which is wonderful. With [a] paper textbook, you really can't have all these options of learning."*

As demonstrated, all the lecturers mentioned that their teaching style is interactive, and they all expressed their views on teaching with e-textbooks. This links the teaching approach directly to the adoption of e-textbooks. At the beginning of the interviews, the lecturers did not have a clear understanding of the differences between an e-textbook and a paper book; however, by the end of the interviews, the lecturers showed greater appreciation for the affordances of e-textbooks. More specific discussion of the lecturers' practices around the use of e-textbooks is provided below.

5.2. Contradiction Analysis of Lecturers' Practices

The interviews conducted with four lecturers that presented contradictions are shown in Figure 2.

A tertiary contradiction is symbolised by (a) in Figure 2 in the lecturers' activity, which arises from a tension between mediational means and division of labour. This contradiction underscores the transformative impact of the e-textbook on the conventional role of the lecturer. With the advent of the e-textbook, lecturers are no longer just content presenters (if, indeed, they ever were). They now face the challenge and opportunity to design and curate enriched learning experiences. For example, Lecturer 2, capturing this sentiment of reliance on the e-text for grasp of the content, noted:

> *"E-textbook makes life so much easier in terms of understanding the content yourself, then being able to deliver the content, and then being able to pursue assessment. It's brilliant."*

This statement suggests that, while e-textbooks aid lecturers in grasping content, effective teaching extends beyond mere understanding. Although e-textbooks can bolster lecturers' comprehension, they still bear the responsibility of conveying content to students in a comprehensive manner, intertwining it with context, insights, and structure. This also raises concerns about diminishing lecturer–student interactions and potential loss of instructional control.

While the e-textbook offers a wealth of resources, the responsibility falls on the lecturer to harness it effectively, ensuring a holistic learning journey. This contradiction captures the evolution from a traditional teaching model to a more culturally advanced, student-centric approach facilitated by the e-textbook. Lecturer 3 further emphasised the need for balance:

> *"I think e-textbooks can definitely assist you in your teaching . . . It's there to support your teaching, not take over. Those lecturers who just use the e-textbook to teach on their behalf need to be cautious."* [Lecturer 3]

This presents a risk: while e-textbooks offer undeniable advantages, relying solely on them could erode the lecturers' active involvement in teaching. Lecturer 3's comment illustrates the importance of maintaining agency and control over the instructional process. This contradiction arises from a clash between the capabilities of e-textbooks, as intermediaries, and the conventional beliefs and roles of lecturers. On the one hand, e-textbooks offer tools and resources that can simplify the teaching process, as articulated by Lecturer 2. On the other hand, there is a realisation, particularly from Lecturer 3, that relying solely on e-textbooks can diminish the active role of a lecturer. The disparity between the capabilities and potential of the e-textbook and the lecturers' actual utilisation of them creates this conflict. Effective teaching goes beyond content comprehension. It is a blend of pedagogical strategies, instructional design, student engagement, and clear communication. A pronounced conflict surfaces when lecturers use e-textbooks primarily for assessment, despite acknowledging their benefits for scaffolded learning. This discord between stated belief and action accentuates the contradiction.

Moreover, Lecturer 1 adds another dimension by highlighting that "*using* [name of an e-textbook platform] *solely for assessment overlooks its potential for enhancing student learning*". This indicates that e-textbooks are not just assessment repositories; they should act as dynamic platforms aiding student performance, monitoring and facilitating various levels of lecturer–student engagement. This contradiction emerges from a double bind because, if lecturers use e-textbooks only for assessments, they miss their pedagogical benefits. However, if they lean too heavily on e-textbooks, they risk diminishing their active role and possibly the quality of student–lecturer interaction. This puts lecturers in a position where they seem trapped between two conflicting demands or constraints.

Additionally, this contradiction speaks to how the role of the lecturer is traditionally conceived, and how the e-textbook has the potential to shift this role. Historically, the role of lecturer is understood in various ways, from "sage-on-the-stage" to learning facilitator. However, as scholars, such as Ahn [5], Gu et al. [7] and others argued, e-textbooks can foster self-regulated learning (Self-regulated learning refers to the process where learners personally initiate and manage their own learning processes. It is not just about the ability of students to study independently, but rather their ability to understand and control their own learning). The objective is not to replace lecturers with e-textbooks, but to leverage them as supplementary tools to demystify intricate engineering concepts. For instance, Lecturer 2's initial response to the question of whether the e-textbook could replace the lecturer was initially affirmative: "*Obviously, I'm a teacher, I never want to agree with it that something can replace me, but the real answer is 'yes'.*" Further discussion with Lecturer 2 elaborated and clarified their response:

> *"It is also child [student] dependent because there are some students who will never be able to function in a classroom but, if you give them a laptop, you give them access to everything. And they still want to be in the classroom being taught something. Yes. So, I wouldn't say replaced, because I feel like some things can be supplemented."*

The lecturer later added a nuance, suggesting that the situation is student-dependent, with some learners thriving in a digital environment. Here, the emphasis is not on replacing lecturers, but supplementing their teachings. This mirrors a broader trend: students leveraging e-textbooks to foster independent learning.

Lecturer 4 identified the role of the e-textbook as a facilitator and his role as follows:

> *". . . lecturer comes in with more effort, especially to cover the background [engineering problem] for the students on what they've been exposed to help them use their imagination. So, e-textbook is linked to content and doesn't really stretch the minds of the students to a point where, if you want to make an example about a particular concept, you want to make an example and you want to bring a typical application of that particular concept. So, an e-textbook won't do that for you. It was just purely to explain what is in the book."*

E-textbooks, while content-rich and enhanced with visualisations and simulations, underscore the lecturer's role in providing contextual understanding and relevant application examples. A notable observation shared by multiple lecturers is the evolving nature of their role. With the advent of e-textbooks and supplementary resources provided by publishers, the primary responsibility of lecturers in content presentation seems to be supported, if not partially replaced. This evolution triggers two prominent concerns: firstly, the potential diminishment of the lecturer's unique role, and secondly, the prospective enhancement in teaching quality when e-textbooks are optimally utilised. From a CHAT perspective, it is crucial to consider the cultural and historical aspects of teaching. Certain lecturers perceive e-textbooks as a constraint, feeling a reduction in their agency and autonomy. This sentiment might stem from the sense of control they possess in traditional teaching contexts. Conversely, some lecturers view the incorporation of e-textbooks as a progressive step, leveraging technology to complement and enrich their instruction [64].

For example, Lecturer 3 elaborated her view regarding e-textbooks and teaching:

> *"Just because there's an e-textbook doesn't mean you can stop teaching, lecturing, and explaining what is happening within that topic. Otherwise, there is a disconnect between the students, the lecturer, and the e-textbook. So, you have to make sure that everybody's working together, and the e-textbook contributes to your teaching, but it doesn't take over your teaching."* [Lecturer 3]

Furthermore, Lecturer 2 shed light on a nuanced challenge: students perceiving lecturers' e-textbook usage as a substitute for active teaching. This speaks to a broader discontent for some students between student expectations, rooted in traditional methodologies, and contemporary teaching objectives.

> *"I found that even with my final year students, when you get to chapters that maybe have a lot of theory . . . And when you direct them to a resource, even if it's a video or something else, the perception that they feel like you're not teaching, you're trying to get away with teaching and you're being lazy, or it's not what they pay for, or those types of vibes, or reactions, or things like that. So I think that might be a disadvantage."* [Lecturer 2]

In the given instance, Lecturer 2 expressed frustration with her experiences. Historically, students were frequently directed on tasks without adequate guidance on effectively managing their individual study and learning routines. The pedagogical approaches adopted became particularly relevant during the challenges posed by COVID-19.

Teaching and learning under social distancing conditions of the global pandemic, from 2020 onwards, brought the case for the use of technology for remote education into focus. The shift to remote teaching and learning made interest in e-textbooks more integral than ever. However, Lecturer 3 captured the essence of the prevailing sentiment:

> *"You are kind of influenced by what is happening around you, for example, the fact that e-textbooks are becoming so popular and common. The pandemic, where we couldn't teach face to face. So, it definitely changes the way you teach and your teaching philosophy because it makes you think about how to make your teaching methods better."*

Lecturer 3 acknowledged the influence of external factors, such as the popularity and ubiquity of e-textbooks, as well as the shift to remote teaching during the pandemic. These factors prompted the lecturer to reconsider their teaching methods and philosophy by seeking ways to improve their instructional approaches. In this extract, Lecturer 3 also agreed that e-textbooks changed their teaching philosophy, but did not explain how and what functions e-textbooks fulfilled, or how they helped this lecturer.

6. Limitations

The limitations of this study include its focus on a single case study of a University of Technology in South Africa, which could limit the generalisability of the findings to other institutions or contexts. While e-textbooks have the potential to enhance access to learning materials, not all students have reliable access to the necessary devices, internet connectivity, or digital infrastructure. In the South African context, disparities in access to these digital tools could present a significant barrier to the effective use of e-textbooks.

Furthermore, the success of e-textbooks may be constrained by the availability of adequate technical support for both students and lecturers. Without sufficient training on how to effectively use these digital resources, their integration into the teaching and learning process may be compromised, reducing their overall impact.

7. Conclusions

CHAT offers a unique and comprehensive lens through which to analyse the integration of e-textbooks, providing insights into how tools, rules, community, division of labour, and the object of the activity interact within an educational setting. This framework not only allows researchers to examine how e-textbooks function as tools within the teaching–learning process, but also to identify the systemic contradictions that may arise. These contradictions between traditional pedagogical practices and new technological tools, for instance, are particularly important, as they highlight the challenges educators and students face when adapting to technological changes.

By using CHAT as a framework, researchers can continue to unpack how technological changes, such as the introduction of e-textbooks, extend beyond the classroom to influence teaching philosophies, institutional policies, and the overall structure of education. This makes CHAT not just a tool for analysing current educational technologies, but a valuable approach for examining the ongoing digital transformation of higher education in future studies.

This tertiary contradiction emerged from conflict regarding the lecturers' perspectives on the role of e-textbooks in their teaching. While some saw e-textbooks as a supplementary tool, others feared the potential overshadowing of their traditional roles. Additionally, lecturers felt a tension between leveraging the e-textbook's capabilities and maintaining their authoritative and guiding role in the classroom.

Furthermore, this contradiction between the e-textbook and the subject (lecturers) is multi-layered, marked by both conflict and a double bind. While e-textbooks present challenges, they also usher in opportunities for pedagogical innovation. However, for optimal outcomes, it is essential to address student concerns about using the text and effectively communicate the benefits of the e-textbook. The tertiary contradiction (a), between mediation means and division of labour, focuses on the transformative role of the e-textbook, prompting lecturers to adopt a more active role in designing meaningful learning experiences. Recognising and addressing these tensions can foster a productive integration of e-textbooks within the educational landscape. To resolve this tension requires a balanced approach, professional development, and training programmes that can equip lecturers with the necessary skills and strategies to effectively design and facilitate learning experiences that optimise the use of e-textbooks.

It would be valuable to discuss more prominently in future research the role of e-textbooks not merely as learning tools, but as a proxy for broader technological change within higher education. E-textbooks represent a shift in teaching practices, reflecting the ongoing digital transformation that is reshaping the educational landscape. By transitioning to e-textbooks, educators are engaging with new pedagogical approaches that require rethinking traditional methods of content delivery and student engagement.

This technological shift can influence teaching practices in several ways. Firstly, it encourages a move towards more interactive and flexible learning environments, where students can access materials from anywhere, at any time, fostering a more student-centred approach. Secondly, the integration of e-textbooks may impel educators to adapt their instructional strategies to leverage the multimedia and interactive capabilities these platforms offer. This can enhance student participation, engagement, and personalised learning experiences.

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Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request. Due to privacy concerns access to the data is restricted and will only be provided to researchers who comply with the appropriate ethical guidelines.

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Article

How Speech–Language Pathologists Adapt This Is Me Digital Transition Portfolios to Support Individuals with Intellectual/Developmental Disabilities and Communication Challenges Across Settings

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Abstract: Critical information is frequently lost when individuals with intellectual/developmental disabilities (I/DD) and co-occurring communication challenges transition from one educational/clinical setting to another. To encourage a seamless transition, speech–language pathologists (SLPs) developed This is Me (TiME), a customizable, digital transition tool designed to help students/patients share personal information and advocate for needed support in their new settings. Researchers conducted a content analysis of 92 TiME transcripts to determine how SLPs used the tool across school and inpatient contexts. Findings indicate the most common content domains included in TiME were personal information (e.g., strengths, hobbies, and preferences) and information about communication, learning styles, and behavior/emotion regulation. While school and inpatient units demonstrated similar patterns of domain use, TiME created in an inpatient context contained more information about behavior plans/supports and were almost twice as long on average. They also included more information about safety and diagnoses/medical needs and less information about self-advocacy strategies than TiME created in school contexts, reflecting the very different settings within which they were created. These findings suggest that TiME offers a solution that can readily be adapted to meet the needs of varied groups of individuals with disabilities as well as different audiences.

Keywords: transition; digital portfolios; self-advocacy; autism; intellectual/developmental disabilities; assistive technology

1. Introduction

Transitions from one educational/clinical setting to another present both opportunities and challenges for individuals with intellectual/developmental disabilities (I/DD) and co-occurring communication issues. Ideally, young people would move seamlessly from one setting to the next, with staff at the former setting passing on information about the individual's existing skills, strengths, and strategies. However, it does not always work this way, and critical information sometimes gets lost in the process (e.g., Black, 2010; Müller et al., 2022). To prevent this from happening and to ensure smooth, successful transitions, speech–language pathologists (SLPs) developed This is Me (TiME), an innovative technology tool, to help students/patients advocate for needed support in their new settings (Pouliot et al., 2017).

TiME is a customized, electronic transition tool intended to help individuals with I/DD and co-occurring communication challenges advocate for the support they need in areas of communication, learning styles and preferences, behavior/emotional regulation, and other key content domains. Individuals may also use the tool to share personal information about strengths, interests, hobbies, and prior work experiences. TiME tools are created by the individual or with support from their team, uploaded to each individual's iDevice, and comprise captioned pictures and video clips to share with new communication partners (e.g., teachers, 1:1 aides, adult service providers, or employers) or in novel settings. This paper analyzes TiME tools created for 92 students/patients to better understand how the tool can be adapted to support the transition process across settings.

2. This Is Me: An Overview

TiME organizes and scaffolds complex information that individuals with I/DD and communication challenges might need additional support explaining independently. Content is selected when educational/clinical teams—including students/patients and families, whenever possible—meet to identify key strategies and strengths to be included in the individual's TiME tool, customized to reflect each individual's unique learning and communication profile.

Following the team meeting, a planning guide detailing the information and strategies to be included in each section scripted from the perspective of the individual is created by the individual's SLP or team member, the digital tool is created using the planning guide, and corresponding pictures/video clips are shot, edited, and added to the digital tool. The information or strategy on each page is recorded and plays with each page as the user moves through the tool. There are many options available for recording, including the individual reading all of the scripts themselves, the individual reading some of the scripts themselves, selecting a communication partner to record on their behalf, or using their speech-generating device voice. The tool can be created on a staff device and transferred to the individual's iDevice once the tool is complete or can be created on the individual's iDevice from the beginning. TiME can be created using a story creation application such as Pictello. The individual or caregiver is then taught to share the tool with relevant communication partners. To the greatest extent possible, individuals with I/DD are involved in making and sharing their TiME tools. For example, some individuals help select the strategies they wish to showcase, record themselves reading their TiME scripts aloud, type and upload their TiME tools to the apps on their iDevices, and/or learn how to share their TiME tools independently or with support. For those with more complex I/DD and/or behavioral concerns, however, these types of participation are not always possible. In these cases, SLPs rely heavily on their relationship with the individual and input from family members and staff with intimate knowledge of their likes and dislikes, strengths, and preferred support strategies. Although beyond the scope of this article, Pouliot et al. (2017) provide a detailed description of the process for creating TiME, and readers can also reach out to authors for access to step-by-step guidelines.

3. State of the Research

This study provides a content analysis of how TiME is used across multiple settings to understand the range of possible uses. TiME tools are intended to (a) serve as digital transition portfolios supporting transition across educational contexts; (b) use a person-centered, strengths-based approach; and (c) foster self-determination and autonomy to the greatest extent possible. The following sections summarize the state of research and practice in each of these areas.

3.1. Transition Portfolios

Although limited in scope, several studies conducted over the past fifteen years suggest that transition portfolios can effectively transmit information about individuals with disabilities during early childhood and/or post-secondary transition (e.g., Black, 2010; Hartley et al., 2014; Müller et al., 2018, 2022). Transition portfolios serve several purposes, including helping prevent the loss of critical information during the transition process, presenting the individual with disabilities in a positive light (i.e., focusing on strengths rather than deficits), and, in some cases, supporting individuals with disabilities to share personal information about themselves with minimal support from others. Although the structure and content of transition portfolios may vary, most present key information about who the individual is, which helps 'humanize' them, including details about their unique strengths, interests, and/or support needs (Müller et al., 2018; Pouliot et al., 2017). They are usually created by support staff (e.g., speech–language pathologists or teachers) from individuals' current programs to be shared with support staff in their new programs, including schools, workplaces, and residential or day programs (Müller et al., 2022; Hartley et al., 2014; Lewis-Dagnell et al., 2024). When possible, transition portfolios can be constructed with input from individuals with disabilities to encourage autonomy and self-determination (Müller et al., 2022; Pouliot et al., 2017). Traditional paper portfolios include examples of schoolwork, resumes, and bulleted lists of strategies for supporting individuals with disabilities to communicate, socialize, follow multi-step directions, and/or manage frustration. Digital transition portfolios like TiME enhance the sharing process by enabling the addition of photos and video clips of how individuals with disabilities learn, work, and communicate, and in some cases, storing the portfolios on their iDevices so they can readily be shared (Black, 2010; Lewis-Dagnell et al., 2024; Müller et al., 2018, 2022).

Although transition portfolios—both paper-based and digital—offer a promising means of supporting the smooth transition of individuals with I/DD from one setting to another, only a few studies have attempted to measure the impact of these tools. For example, Clancy and Gardner (2017) described using ePortfolios with an entire special education high school to ensure that information about students traveled with them as they transitioned to post-school settings, but no outcome data were gathered. Studies that have attempted to quantify the impact of transition portfolios include two articles on the use of 'I am' Digital Stories, 3–5 min videos that place the voices of autistic children and young people in the center of transition planning by capturing video clips and statements about what the person likes doing and is good at, and how they feel most supported (Lewis-Dagnell et al., 2024). For example, Wood-Downie et al. (2021) conducted a series of interviews and focus groups to determine whether stakeholders (i.e., parents, nursery school staff, and educational psychologists) believed Digital Stories could be helpful during transitions from pre-K to elementary school and stakeholders were unanimous in endorsing the tool. A second study of Digital Stories was conducted by Lewis-Dagnell et al. (2024) and included 17 interviews with stakeholders (e.g., parents, school, and professional staff), all of whom agreed that the tool could be an effective means of supporting the transition of autistic students from high school to post-school life.

Two studies of TiME were also conducted. The first, by Müller et al. (2018), was based on interviews with nine employers, all of whom reported significant increases in their knowledge of young adults with disabilities' communication strategies, as well as improved confidence supporting their workplace communication, following the viewing of young adults' TiME. The second, by Müller et al. (2022), paired 17 transition-aged students with I/DD and co-occurring communication support needs with a novel adult (i.e., someone who was unfamiliar with the individual with I/DD). Using a randomized control design, the researchers compared novel adults' knowledge of students before and after viewing their TiME and found that following the sharing of students' TiME tools, new adults could describe significantly more about students' support strategies and other personal information than following unaided conversation.

3.2. Person-Centered/Strengths-Based Approach

Over the past few decades, there has been significant movement towards a more person-centered approach to serving people with I/DD that individualizes services rather than insisting on a one-size-fits-all (Kaehne & Beyer, 2014). According to a systematic review of person-centered planning (PCP) by Ratti et al. (2016), PCP places the individual at the center of the planning process; includes family members and friends as key partners in planning; develops goals/objectives that reflect what is most important to the person, their strengths and their support needs; and emphasizes equality and empowerment. Ratti et al. further note that PCP breaks from traditional approaches where planning is done *for* individuals with I/DD, and instead strives to support individuals with I/DD (with active input from those who know and love them) to engage as fully as possible in driving the planning/decision-making process themselves. This is based on the "nothing about us without us" ethos that emerged in the 1990s as part of the disability rights movement.

Significantly, PCP takes a strengths-based approach that emphasizes building on the person's skills, abilities, and interests rather than focusing on remediating deficits (Ratti et al., 2016). This strengths-based approach has been embraced and magnified by neurodiversity advocates who stress that the unique strengths, challenges, and differences that characterize each neurodiverse person (including autistic individuals and those with I/DD) are central to who they are and should not be seen as something to be 'fixed' (Sarrett, 2016; Kapp et al., 2013).

A limited body of literature has emerged that indicates PCP can result in positive outcomes for individuals with I/DD. For example, a systematic review conducted by Claes et al. (2010) found that the effectiveness of a person-centered approach was most apparent in variables related to reductions in challenging behaviors, improvement in social networks, community involvement, and issues related to the planning process itself (e.g., levels of involvement of the person and their family, improvements in communication, teamwork, and development of a more comprehensive and cohesive vision for the person's life). Similarly, a more recent systematic review by Ratti et al. (2016) found that PCP appeared to have a moderate impact on several outcomes for individuals with I/DD, particularly community participation, participation in activities, and daily choice-making. Finally, a study of 65 individuals with I/DD by Wigham et al. (2008) found that almost half reported that a key benefit of PCP was improved happiness and self-esteem.

Because the voices of individuals with I/DD—especially those with co-occurring communication support needs—are frequently left out or excluded from education and transition planning, person-centered digital portfolios like TiME and 'I am' Digital Stories are designed to place these missing voices front and center (Lewis-Dagnell et al., 2024; Müller et al., 2022).

3.3. Self-Determination

Self-determination refers to a person's ability to make choices and demonstrate agency within the context of their life and is intimately connected to self-awareness of one's strengths, preferences, challenges, and needs. All of these aspects are crucial components of one's ability to advocate for help (Thompson-Hodgetts et al., 2023). Self-determination is also a key factor in determining the post-school success of students with I/DD and co-occurring communication challenges (Mazzotti et al., 2021). For example, research suggests that self-determined behavior and opportunities for autonomy/decision-making during the school years contribute to positive outcomes related to employment, post-secondary education, and independent living (Callahan et al., 2011; Lindstrom et al., 2011; Mazzotti et al., 2014, 2021). While research indicates that students with I/DD can be taught self-determination skills, including asserting preferences (Sheppard & Unsworth, 2011), several studies also suggest that individuals with more significant disabilities (e.g., I/DD including autism) have fewer opportunities to engage in self-determined behavior (Simões et al., 2016). Vicente et al. (2020) argue that teachers and related service providers who work with individuals with I/DD must create opportunities for them to practice self-determination—for example, communicating their strengths and needs and requesting necessary support.

Significantly, a study by Nota et al. (2007) suggests that one's level of disability/support needs is less likely to predict self-determination than the frequency of opportunities to engage in self-determined behavior. Wehmeyer et al. (2011) argue that the degree to which transition-aged students achieve self-determination is more a function of *context*—and the supports available within those contexts—than of intellectual or cognitive capacity. In a more recent article by Wehmeyer and Shogren (2017), they elaborate on this concept by explaining that autonomy (a component of self-determination) is frequently and mistakenly equated with independence since making one's needs and wishes known—including asking for help when needed—*is* an expression of autonomy. This suggests that tools like TiME can promote autonomy and self-determination for individuals with I/DD and co-occurring communication challenges by creating opportunities for them to learn about their strengths and needs, identify strategies that best support them in their educational and work environments, share vital information about themselves—either independently or with support from another adult, and request help from others.

4. Purpose

To better understand how SLPs use TiME to support their students/patients with I/DD and co-occurring communication challenges as they transition between contexts (e.g., educational, clinical, and other community settings), researchers conducted a content analysis of 92 TiME story transcripts across school and inpatient clinic settings. As part of this study, we asked the following quantitative questions:

(1) How much information was provided within TiME transcripts (i.e., average # of sentences per story)?
(2) For which *content domains* did SLPs provide information using TiME (i.e., personal information, communication, learning styles/preferences, behavior, self-advocacy, diagnostic/medical, motor skills, and safety), and are some domains more heavily supported using TiME than others?
(3) Which *information types* did SLPs most frequently use (i.e., informational statements vs. recommended strategies)?
(4) Do trends in the use of content domains and information types differ across settings?

We also identified examples of how TiME transcripts commonly included information about students/patients (e.g., range of themes within domains, types of statements/strategies used repeatedly across students/patients).

5. Methods

5.1. Data Set

Researchers reviewed TiME transcripts from three different contexts (two non-public schools and one inpatient unit) in urban/suburban Maryland. Retrospective analyses were conducted of 92 deidentified TiME transcripts created over six years. To maintain confidentiality, stories were first de-identified by students/patients' SLPs and then transcribed verbatim by members of the research team.

A total of nine SLPs had spearheaded the development of TiME. SLPs all held master's degrees or higher and were licensed in Maryland. They all identified as White and female, ranged in age from 20 to 55 years, and had worked at their current job sites from two to twenty years. School-based TiME tools were also reviewed by students' educational team members, which, in addition to the student, potentially included their vocational specialist, employment coach, special education teacher, program coordinator, mental health provider, board-certified behavior analyst, 1:1/paraprofessional, occupational therapist, physical therapist, transition specialist, and/or parents.

The 59 students at the two *schools* for whom TiME tools were created ranged in age from 16 to 23 years. Most students attending these non-public schools demonstrated such complex support needs that their designated public schools could not appropriately serve them. All 59 students had I/DD, with primary educational diagnoses including autism, Down syndrome, Fragile X syndrome, other health impairments, and multiple disabilities. Most were performing several levels below grade level and pursuing high school certificates of completion rather than diplomas.

The 33 patients for whom TiME tools were created at the *inpatient unit* ranged in age from 6 to 21 years. The 16-bed inpatient unit was dedicated to the assessment and treatment of children and young adults with I/DD who engaged in severe and treatment-resistant problem behavior. The program served patients across the country and around the world. All 33 patients included in this study had I/DD, as well as autism, sleep and feeding disorders, stereotypic movement disorder with self-injurious behavior, and various genetic and/or metabolic and chromosomal disorders.

Although all 92 students/patients experienced co-occurring language challenges, communication skills varied considerably. Some used augmentative and alternative communication (AAC)—including high- and low-tech devices, pictures, gestures, and modified signs—to communicate. Some communicated verbally using simple one- to two-word phrases. Some experienced speech sound disorders that negatively impacted speech intelligibility. Others spoke in longer sentences but engaged in frequent off-topic monologues and did not limit their responses to relevant details. All needed support describing their strengths and/or advocating for their support needs. Institutional review boards approved the retrospective analyses of the 92 de-identified TiME transcripts.

5.2. Data Collection and Analysis

To prepare the data corpus, all 92 TiME tools were transcribed verbatim by SLPs at each of the three research sites. These transcripts captured the written content on each page of the TiME tool, including both informational statements and recommended strategies. De-identified transcripts were then shared with members of the research team. Content analysis took place in several stages. First, the entire team reviewed a sample of six transcripts and suggested major content domains and information types for inclusion in the analysis. The first author then reviewed a larger sample of transcripts using these initial coding categories to ensure the team was not overlooking anything significant, made minor modifications to the coding system, and created a codebook to ensure reliable coding. Entries for each code included a definition, instructions for when and when not to use the code, and illustrative examples. The first author then coded all 1200 sentences found in the 92 transcripts for (a) content domain and (b) type of information.

Content domains included the following coding options (see Table 1 for examples of typical sentences falling within each content domain):

- Personal Information (P)—This code was used for sentences about family, interests/hobbies, personality traits, work experiences/formal jobs, things that are difficult due to disabilities, and generic likes and dislikes.
- Communication (C)—This code was used for sentences about communication modalities, expressive strategies (i.e., how the individual communicates), receptive strategies (i.e., how best to speak to the individual), communication challenges, managing conversation breakdowns, and issues related to processing time during communication.
- Learning Tools and Preferences (L)—This code was used for sentences that referred to learning challenges (e.g., distractibility, difficulties transitioning from one activity to another) and learning supports (e.g., preferences for work/learning environment, schedules/checklists, need for adult support/praise, and environmental modifications).
- Behavior/Emotion Regulation (B)—This code was used for sentences related to challenging behaviors, emotional upset of any kind, strategies to support emotion regulation/sensory dysregulation, behavior plans, and reinforcers.
- Asking for Help (H)—This code was used for sentences referring to the individual's ability to self-advocate/ask for help, or how adults can support the individual's self-advocacy.
- Diagnostic/Medical (D)—This code was used for sentences referring to diagnoses or other medical conditions/needs such as allergies, seizures, overheating, medications, eyeglasses, feeding tubes, and movement breaks.
- Mobility/Motor Issues (M)—This code was used for sentences referring to gross and fine motor control, how the individual sits/stands/walks, and any adaptive tools necessary to support mobility/motor functioning (e.g., adaptive scissors).
- Safety (S)—This code was used for sentences referring to any dangers to be aware of that are not included under another category, as well as strategies for supporting the individual's safety.

Information type included the following coding options:

- Informational Statement (I)—This code was used for sentences that provided information about the individual but were not stated as directives.
- Recommended Strategy (R)—This code was used for sentences formulated as directives.

To determine how much information was included in TiME scripts, we averaged the number of sentences included in TiME scripts across schools, the inpatient unit, and all sites combined. To determine how often TiME transcripts referenced each content domain, we counted each sentence coded for the content domain within transcripts and calculated the mean frequency across schools, inpatient unit, and all sites combined. We also calculated the frequency of sentences referencing each content domain as a *proportion* of the total number of sentences across schools, inpatient unit, and all sites combined. These same calculations were conducted for each information type. To determine if the frequency with which content domains and/or information types were mentioned differed significantly across settings (i.e., between schools and the inpatient unit), we compared means for each. Statistical significance was calculated using a series of two-tailed t-tests, and p-values of less than 0.05 were reported.

Table 1. Examples of typical TiME content.

Personal Information	
Likes and Hobbies	*"I like hearing jokes and laughing with you".* *"I like to voice characters such as Barney, Batman, and Bugs Bunny".* *"I like to go swimming, for walks, and visit elevators".*
Resume and Work Experience	*"At Walgreens, I worked on stocking shelves, cleaning the floor, and organizing drinks in the refrigerator".*
Communication	
Communication Modalities	*"I use a speech-generating device".* *"I'm a nonverbal communicator. This means I don't talk. I communicate by looking at objects, physical leading, and reaching".* *"I'm a verbal communicator. I talk to you using single words and short phrases".*
Supporting Receptive Lang	*"Say my name to get my attention. Wait until I look at you to speak".* *"Give me one direction at a time".* *"Speak slowly".* *"Use 2–5 words when asking questions and giving directions".*
Supporting Expressive Lang	*"Sometimes it can be hard to understand my words. If you are having trouble understanding me, let me know by saying, 'I didn't understand'".* *"Written and visual choices help me answer".* *"Give me time to think".*
Learning Styles/Preferences	
Learning Strengths and Challenges	*"I am good at sorting by shape and color".* *"I get distracted easily".*
Ideal Learning Environment	*"It helps if you keep materials out of my work area until I'm ready to use them".* *"I like working in quiet places where it is not crowded".* *"I like routines".*
Tools and Strategies	*"I can set alarms to help me remember".* *"Checklists and schedules help keep me on track".* *"I learn best when people model new tasks and show me what to do".* *"I may need a human reader and scribe to help me with reading, writing and typing".* *"I like it when you praise me for my work".*
Behavior/Emotion Regulation	
Challenging Situations	*"Some things that make me upset are loud and unexpected noises"*
Challenging Behaviors	*"Sometimes when I feel frustrated or overwhelmed, I bite my hand and yell loudly".* *"My problem behaviors include grabbing and hitting others and hitting my head".*
Behavioral Support	*"If I am upset, help me by asking, 'What do you want?' and pointing to my iPad".* *"I can use different strategies when I feel frustrated. They include deep breathing, hand squeezes, and talking to an adult I trust".* *"Please block any head-directed self-injurious behavior to keep me safe".*
Supporting Self-Advocacy	*"When I need help, I am learning to say, 'Please help me.'"* *"Sometimes I ask for help when I don't need it. Ask me to try and solve the problem first".*
Diagnoses and Medical Conditions	
Diagnoses/Medical Conditions	*"I have seizures".* *"I also have a mood disorder and disruptive behavior disorder".*
Support Strategies	*"I wear a medical bracelet".* *"I wear glasses when I read".* *"I self-feed a regular diet, but have a gastronomy tube".*
Mobility/Motor Challenges and Supports	*"When I am walking down the stairs, I hold the railing and take one step at a time. Someone needs to stand behind me".*
Safety Issues and Supports	*"I love dogs, but I may not read their cues. Please watch me closely around unfamiliar animals".* *"I'm really fast and may run away from you in parking lots and public places. Please hold my hand and stay close to me".*

5.3. Inter-Rater Reliability

Inter-rater reliability for the coding system was assessed by having the second author code a random sample from each of the three sites, or 30% of the 92 TiME transcripts. Inter-rater reliability was calculated by dividing the total number of agreements between the first and second authors by the total number of disagreements between the two authors and multiplying by 100. Inter-rater reliability was 89.5% for content domains and 96.1% for information types.

6. Results

6.1. Information Overall

On average, TiME transcripts across all site types were 49.35 sentences in length (see Table 2). TiME transcripts created by the inpatient unit tended to be more than twice as long as TiME transcripts created by the schools (means of 76.79 versus 34.0 sentences, respectively).

Table 2. Mean occurrences and percentages of each content domain and information type within TiME transcripts.

	Across School Sites		Inpatient Unit		Across All Sites	
	Mean	**Percentage**	**Mean**	**Percentage**	**Mean**	**Percentage**
Content Domain						
Personal Information	6.54	*(19%)*	12.67	*(16%)*	8.74	*(18%)*
Communication	10.63	*(31%)*	18.45	*(24%)*	13.43	*(27%)*
Learning Tools and Preferences	8.02	*(24%)*	18.09	*(24%)*	11.63	*(24%)*
Behavior/Emotion Regulation	2.10	*(6%)*	16.15	*(21%)*	7.14	*(14%)*
Asking for Help	1.05	*(3%)*	1.58	*(2%)*	1.24	*(3%)*
Diagnostic/Medical	0.83	*(2%)*	3.39	*(4%)*	1.75	*(4%)*
Mobility/Motor Issues	0.31	*(1%)*	0.64	*(1%)*	0.42	*(1%)*
Safety	0.1	*(0%)*	1.39	*(2%)*	0.57	*(1%)*
Other	4.42	*(13%)*	4.42	*(6%)*	4.42	*(9%)*
All Content Domains	**34**	***(100%)***	**76.79**	***(100%)***	**49.35**	***(100%)***
Information Type						
Informational Statement	20.1	*(59%)*	54.45	*(71%)*	32.43	*(66%)*
Recommended Strategy	13.4	*(41%)*	22.33	*(29%)*	16.91	*(34%)*

6.2. Content Domains

The most common content domains across sites were communication (mean = 13.43 or 27%), learning tools and preferences (mean = 11.63 or 24%), personal information (mean = 8.74 or 18%), and behavior/emotion regulation (mean = 7.14 or 14%) (see Table 2). Mean occurrences for all other domains (i.e., asking for help, diagnostic/medical, mobility/motor issues, and safety) were mentioned on average less than five times per story transcript. The four content domains most common across all sites were also the most common across each of the two site types, but while school transcripts followed the same order of frequency, patterns for the inpatient unit were somewhat different: For the inpatient unit, the first two content domains were still communication (mean = 18.45 or 24%) and learning tools and preferences (mean = 18.09 or 24%), but behavior/emotion regulation (mean = 16.15 or 21%) came in third, instead of personal information (mean = 12.67 or 16%).

When comparing mean number of mentions of each content domain across sites, we found highly significant differences (i.e., *p*-values of <0.001) for all domains except asking for help (i.e., *p*-value of <0.05) and mobility/motor issues for which there were no significant differences (see Table 2).

6.3. Information Types

Informational statements were the most common information type across sites (mean = 32.43 or 66%), and recommended strategies were somewhat less common (mean = 16.91 or 34%) (see Table 1). We found the same pattern when looking at data for each of the site types, but again, numbers were much higher for both categories within TiME transcripts created for the inpatient unit, as stories were longer. When comparing the mean number of information types across sites, we found significant differences for both informational statements and recommended strategies (i.e., *p*-values of <0.001) (see Table 3).

Table 3. Comparing TiME content across site types.

	Schools		Inpatient Unit		Differences		*t* Stat	Effect Size
	(n = 59)		(n = 33)		Across Site Types			
	Mean	SD	Mean	SD	Mean	SD		
Content Domain								
Personal Information	6.54	(6.36)	12.67	(5.37)	6.12	(3.24)	8.71 **	1.89
Communication	10.63	(5.61)	18.45	(5.39)	7.83	(3.26)	11.05 **	2.4
Learning Tools and Preferences	8.02	(4.48)	18.09	(6.61)	10.07	(3.99)	11.6 **	2.52
Behavior/Emotion Regulation	2.1	(3.07)	16.15	(6.41)	14.05	(3.89)	16.6 **	3.61
Asking for Help	1.05	(0.9)	1.58	(0.94)	0.52	(0.98)	2.47 *	0.54
Diagnostic/Medical	0.83	(1.76)	3.39	(2.09)	2.56	(1.47)	8.0 **	1.74
Mobility/Motor Issues	0.31	(1.28)	0.64	(1.32)	0.33	(1.12)	1.36	0.3
Safety	0.1	(0.55)	1.39	(1.9)	1.29	(1.39)	4.27 **	0.93
Other	4.42	(2.38)	4.42	(1.46)	0	(1.16)	0	0
Information Type								
Informational Statement	20.12	(11.01)	54.45	(12.67)	34.34	(7.51)	21.03 **	4.57
Recommended Strategy	13.88	(5.98)	22.33	(6.16)	8.45	(3.71)	10.49 **	2.28

** $p < 0.001$, * $p < 0.05$. Effect size of >0.02 = small, >0.05 = medium, >0.08 = large.

6.4. Typical Story Content

Based on an informal qualitative analysis of the TiME transcripts, we describe the most common ways information from the eight content domains was shared and any apparent differences between how the schools and inpatient unit shared information about students/patients' strengths and support needs (see Table 1 for examples of typical TiME content within each content domain).

Personal information. All TiME transcripts contained some content (i.e., two or more sentences) providing personal information. Nearly all of this content was strengths-based, not deficit-based, emphasizing interests, hobbies, skills, and other details that presented students/patients as unique, multi-faceted, and likable. The two school sites, where TiME tools were created in preparation for post-school transition, also frequently included information about students' resumes/job experiences (e.g., names of employers, and key responsibilities such as shelving books, bagging groceries, delivering mail, and wiping down tables). In terms of TiME format, both school sites and the inpatient unit tended to begin TiME transcripts with personal information about students/patients.

Communication. All TiME transcripts contained at least some content about communication, and information about students'/patients' communication styles and strategies was the most consistent across sites. For example, most TiME transcripts contained information about student/patient's communication modalities (e.g., speaking versus non-speaking communication, low- and high-tech AAC options). Most TiME transcripts contained content about how to support receptive communication, including getting the student/patient's attention (e.g., say my name), the maximum number of words to use when addressing the student/patient, and the importance of breaking instructions into manageable chunks. Most TiME transcripts also included content about how best to support the student/patient's expressive communication (e.g., the need for wait/processing time, the benefit of written and visual choices, and the importance of letting the student/patient know if you do not understand what they said so they can repair the breakdown). Many of the TiME transcripts created by the three sites divided the communication section into separate sub-sections (e.g., "How to Talk to Me", "How I Talk to You", and How I Interact").

Learning tools and preferences. All TiME transcripts contained at least some content about learning tools and preferences, although emphases varied across site types. Transcripts commonly included information about the student/patient's learning strengths (e.g., understanding math concepts, tech literacy), learning-related challenges (e.g., distractibility, motivation issues), ideal learning environment (e.g., quiet, uncluttered spaces), and other learning preferences (e.g., hands-on learning, predictable routines). Most commonly, TiME transcripts contained information about preferred tools and strategies for learning (e.g., setting alarms, following schedules, modeling new tasks, and enthusiastic praise). There were no apparent differences in story content across sites or site types.

Behavior/emotion regulation. Information addressing this content domain varied more dramatically across site types than any other domains. TiME transcripts created at the inpatient unit always included content (i.e., between three and 40 sentences) about behavior/emotion regulation. This was not true for the school sites, both of which only sometimes included information about students' behavioral challenges/support needs, and when they did, included minimal information addressing this content area (i.e., no more than 2–3 sentences). When provided, behavioral content across sites commonly included information about challenging situations for students/patients (e.g., loud noises, changes to schedule, non-preferred tasks), their most challenging behaviors (e.g., grabbing and hitting others, self-injurious behavior, property destruction, yelling, and escape/avoidance), and strategies for supporting students/patients through difficult situations (e.g., talking/moving calmly around the student/patient, encouraging them to take breaks, offering hand squeezes). TiME transcripts developed for the inpatient unit also frequently provided detailed information about patients' behavior plans and instructions on keeping patients and others safe during behaviorally difficult moments.

Asking for help. Although there was only a minor amount of content across TiME transcripts dedicated to addressing how students/patients asked for help or were working on self-advocacy goals, almost all TiME transcripts contained at least some content (i.e., one to two sentences) about this. Primarily, transcripts provided information on students/patients' goals related to self-advocacy, and strategies for supporting goal mastery in this area. School sites were more likely than the inpatient unit to include information about self-advocacy goals.

Diagnostic/medical. This was not a major content domain. Information typically included names of students/patients' diagnoses and medical conditions (e.g., autism, intellectual disability, ADHD, Prader–Willi Syndrome, mood disorder, seizure disorder, allergies, and pica), as well as strategies for supporting these conditions (e.g., reading glasses, gastronomy tube, medical bracelet). As with behavior/emotional regulation, TiME transcripts created by the inpatient unit usually contained more extensive information about patients' diagnoses and medical support needs.

Mobility/motor issues. Only a few TiME transcripts from the three sites included information on mobility/motor issues since only a few students/patients required special support in this area. One of the two schools never included information on mobility. Types of information included in this section primarily addressed motor challenges (e.g., walking down stairs, sitting down in a chair, fine motor tasks, and gross motor stamina), as well as strategies for support (e.g., providing physical supports, offering adaptive tools, using orthotics or a wheelchair).

Safety. Although only a few TiME transcripts created by schools included safety information, most TiME transcripts created by the inpatient unit included at least minimal content (e.g., one or two sentences) about keeping the patient safe. Typically, transcripts identified key safety issues (e.g., being around water, interacting with animals, running across streets), as well as strategies for supporting students/patients (e.g., providing careful supervision in these contexts and, in some cases, holding hands).

Summary. Overall, each site developed idiosyncratic ways of creating TiME tools that used similar content across students/patients, as well as recurring transcript structures, while still retaining enough variation to reflect individual student/patient profiles.

7. Discussion

Findings from this study contribute to the field in several ways. First, based on our analysis of TiME transcripts across three sites and two different site types, it appeared the tools consistently addressed a wide range of content areas—providing holistic portraits of individual students/patients as opposed to focusing solely on one domain or another. Overall, some content areas were represented more frequently and comprehensively than others. For example, communication and learning styles/preferences almost always included more detail than areas like motor/mobility challenges and safety. This seemed to reflect the orientation of the tool towards individual student/patient goals and the content of those goals. As with IEPs, certain domains naturally received more attention than others.

The multi-disciplinary nature of the content included in all 92 TiME tools also reflected the collaborative teaming that goes into the creation of TiME. As mentioned earlier, TiME is the product of input not only from the individual's SLP but also from the individual's entire educational/clinical team, including—whenever possible—the student/patient and their family. By involving everyone who knows the individual, TiME captures the multi-dimensionality of each student/patient.

Our findings further indicated that TiME transcripts varied considerably in length. Stories created with and for students transitioning from high school and post-high school to adult settings tended to be shorter than those created for patients transitioning from an inpatient unit back to their schools. This made sense, given the different audiences for whom these tools were created. For transition-aged students at the two schools, tools were created primarily for sharing with adult service providers by the students themselves or with minimal support from a teacher or job coach. Because students' attention support needs were often variable, creating and sharing shorter stories made sense. It is much easier to stay focused while sharing a 20-page story than a 40-page story. Furthermore, one of the original goals of TiME was to capture the individual's 'voice' as much as possible, which meant creating scripts that used concise, easily comprehensible words and sentences that matched the language levels of the individual sharing the tool.

In contrast, stories created at the inpatient unit incorporated input from the entire clinical team (including parents/guardians), but direct input from the patients themselves was typically limited to their personal information. This was because most patients experienced significant I/DD, their behavioral challenges and support needs were complex, and their receptive/expressive vocabularies tended to be very limited. Stories created at this site were intended as training documents to be shared by parents when their children transitioned from the inpatient unit into their new educational settings. Because TiME was designed for use with teachers, BCBAs, and other educational professionals, it made sense to include more technical details. Although creating and sharing their stories was not a central feature of TiME for patients, SLPs and families noted that the person-centered nature of TiME nonetheless provided an important counterpoint to the standard clinical reports and other documents focusing solely on patients' deficits. Several parents noted that TiME highlighted their child's strengths and skills they were bringing to their new schools, setting a positive tone and potentially alleviating some of the anxiety surrounding the transition.

TiME content also varied significantly across site types. This was likely because the two settings used TiME to meet different aims and target different users/audiences. For example, the most significant content difference was the amount of information focusing on behavior. Because the inpatient unit catered to patients with intensive behavioral support needs, it made sense for SLPs to adapt TiME to include comprehensive information about patients' behavioral challenges and behavior plans. Similarly, TiME created by the inpatient unit often contained more extensive information about patients' diagnoses and medical conditions. Again, this is likely explained by the fact that these individuals tended to present with more complex medical needs and conditions than those attending the two schools. Some individuals/families in school settings also opted out of sharing specific diagnostic information as part of their TiME tools because they did not want to share potentially stigmatizing information with employers and coworkers (Lindsay et al., 2021). TiME tools created at the inpatient unit also included more safety-related content. This was unsurprising, given the much higher levels of challenging behaviors, including self-injury, aggression, and escape/avoidance (Sakai et al., 2014). Finally, there were fewer self-advocacy goals in TiME tools created at the inpatient unit than at schools. This was likely influenced by the relative ages of patients (many of whom were still in elementary and middle school) and students (who were all in high school or post-high school). Developing self-advocacy skills is a key component of preparing for secondary transition, regardless of developmental level, but is not usually as central a goal for younger children (Zuber & Webber, 2019).

The TiMe tool's strengths-based approach, customizable platform, and first-person perspective relayed the students/patients in a more humanizing and empowering light. The fact that TiME tools are strengths-based, customized, and told from the point of view of the individual also helped humanize them. All transcripts were made up of "I" statements and began with several examples of the individual's likes and dislikes, hobbies and interests, and ways in which teachers and peers could interact with them (e.g., telling jokes, exchanging high fives). In general, TiME tools stayed focused on the positive, and past studies of TiME based on interviews with employers and job coaches suggest that the experience of viewing the individual's TiME tool often improves attitudes toward them and fosters feelings of personal connection (Müller et al., 2018, 2022).

The tool can also empower viewers of TiME. For example, information like "It is hard for me to make eye contact with others. Even though I may not look at you while we're hanging out, I'm glad you're spending time with me", can help reduce anxiety on the part of new adults unfamiliar with the patient. Especially given that many of the patients for whom TiME tools were created had a history of aggressive, disruptive, and dangerous behaviors, TiME played a critical role in supplying viewers with tools for communication and positive interaction.

7.1. Practical Implications

For SLPs considering the possibility of using TiME with their students/patients, findings from this study provide positive evidence that the tool can be meaningfully adapted to various populations, settings, and audiences. The two types of settings included in this study were quite different, and yet SLPs were able to customize tools for use with both. Readers can consult Table 1 if interested in creating TiME tools for their students/patients.

The option of including individuals in the creation and sharing of their tools, while not always possible, is a key feature of TiME. Involvement in the process can help facilitate students' learning about their strengths and preferences. For example, including information in TiME scripts about specific accommodations in their IEPs builds students' self-awareness and, by reinforcing this information, can better position students to advocate for needed support.

Participation in creating and customizing their TiME tools also supports self-determination. As Vicente et al. (2020) indicate, opportunities for choice-making play a key role in self-determination. The process of designing their personal TiME tools creates opportunities for individuals to choose which pictures and videos they wish to include, select fonts and background colors, and make other decisions about the form and content of their TiME—all of which foster a sense of agency.

TiME tools can also be used to support recall skills and increase accountability. For example, making and sharing the tool serves as a prompt when the student is viewing it with a novel adult. By reminding students of their specific skills and strategies, TiME may reinforce the likelihood of their use. In terms of accountability, when a student shares their TiME tool with a new adult in their lives, and the TiME tool includes information (for example) about the student's self-advocacy goals, they are reminded that this other adult is now aware of the student's tendency to ask for help when they do not need it. This may increase the likelihood that the student will first try to complete a task independently before requesting help.

7.2. Limitations and Future Directions

As mentioned earlier, despite the intuitive appeal of digital portfolios, there is a lack of research in this area. There have now been several studies about TiME, including analyses of stakeholder feedback on their impact and value, and measures of growth in knowledge following exposure to transition-aged students' TiME (Müller et al., 2018, 2022), but there is still a need for more research to help establish digital portfolios—and TiME specifically—as evidence-based tools. To this end, we recommend future research that continues to measure the impact of TiME on a wide range of team members across a wide range of settings. For example, TiME could potentially be used with students who are deaf/hard of hearing or experiencing traumatic brain injury.

Given the promising nature of TiME, we recommend the future expansion of its use to any student/patient with I/DD and communication support needs transitioning to a new learning environment. Some of the ways to increase the adoption of TiME include (1) encouraging schools and inpatient clinics to adopt policies requiring the creation of TiME for all eligible students/patients, (2) developing IEP goals and/or creating self-advocacy groups so SLPs and teachers have time to integrate the making and sharing of TiME into students/patients' schedules, and/or (3) involving transition coordinators early on in the process of creating TiME to serve as liaisons between the current school/inpatient setting, families, and new providers/schools—thereby increasing the social validity of the tool and promoting stakeholder buy-in.

8. Concluding Remarks

This study breaks new ground by examining how SLPs working with various neurodiverse populations or profiles used TiME to support transition from educational/clinical settings to new learning environments and to share relevant information with novel communication partners. Findings suggest that the tool can be adapted for different groups and audiences—and that content and length will vary based on different aims. This article contributes to the small but growing body of literature on TiME and encourages further exploration of its many possibilities.

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Article

Promoting Agency Among Upper Elementary School Teachers and Students with an Artificial Intelligence Machine Learning System to Score Performance-Based Science Assessments

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Abstract: As schools increasingly adopt multidimensional, phenomenon-based, digital-technology-enhanced science instruction, a concurrent shift is occurring in student performance assessment. Assessment instruments capable of measuring multiple dimensions must incorporate constructed responses to probe students' ability to explain scientific phenomena and solve problems. Such assessments, unlike traditional multiple-choice tests, are time-consuming and labor-intensive for teachers to score. This study investigates the potential of an artificial intelligence machine learning system (AI-MLS) to address two critical questions: (1) How accurately can the AI-MLS replicate human scoring of multidimensional science assessments? and (2) How can the implementation of AI-MLS promote educational equity and reduce teacher workload? The present paper describes the development of the AI-MLS to rapidly and accurately score third- to fifth-grade students' constructed responses on multidimensional science assessments. It summarizes key findings from the study, discusses findings in the broader context of fostering agency through digital technology, and offers insights into how artificial intelligence technology can be harnessed to support independent action and decision-making by teachers and students.

Keywords: artificial intelligence; machine learning; performance assessment; science education; teacher agency; student agency

1. Introduction

1.1. Context and Importance

Current U.S. policy emphasizes the importance of science as the foundation for decision-making and advocates for the use of best science practices (White House, 2021). Enhancing K–12 education to boost science, technology, engineering, and mathematics (STEM) literacy, and to inspire students to pursue STEM careers, is a key component of this policy (National Science and Technology Council, 2018). Specifically, the Next Generation Science Standards (NGSS) provide guidance for improving K–12 education through the integration of computational thinking and engineering standards in science instruction. NGSS, as well as other adopted standards and curricula, also encourage the incorporation of mathematics and technology in STEM education (National Research Council, 2012).

The NGSS, now a decade old, stress the significance of cultivating a profound understanding of science, such that students can apply relevant knowledge and skills to explain phenomena and solve real-world problems. There is now a critical need for empirical evidence of the effectiveness of coherent, NGSS-aligned performance-based assessments to foster students' "knowledge-in-use"—a fundamental aspect of NGSS. Knowledge-in-use implies adaptive thinking that enables students to apply their knowledge to explain novel and real-world phenomena or solve complex problems with context-specific solutions, including iteratively considering and making use of multiple practices or ideas (Li et al., 2024).

To develop students' deep science understanding and application of knowledge to real-world phenomena, educators need instructional and assessment materials that integrate three dimensions: disciplinary core ideas, scientific and engineering practices, and crosscutting concepts. According to A Framework for K–12 Science Education, a student's ability to integrate these three dimensions into practice, also termed three-dimensional understanding, is indicative of a deep conceptual understanding (Kaldaras et al., 2022). This means that NGSS-aligned assessments should measure student ability to integrate relevant disciplinary core ideas, scientific and engineering practices, and crosscutting concepts in explaining phenomena and solving problems. To accurately measure three-dimensional understanding, assessments must allow students to demonstrate their ability to integrate all the relevant NGSS dimensions. However, this three-dimensional ability is very hard to measure using traditional recall-based assessment items, especially in a multiple-choice format (Krajcik, 2021). With the adoption of the NGSS, the emphasis has shifted away from rote memorization toward knowledge-in-use proficiencies. A concomitant shift is necessary for NGSS-based assessments—away from multiple-choice tests toward multidimensional performance-based measurement. Assessments must accurately gauge a student's higher-order thinking skills and deep understanding of science concepts, in addition to supporting student progress with multidimensional reasoning, creative thinking, and problem solving. For this purpose, constructed-response items and multidimensional performance-based measurements are required (Kaldaras et al., 2022; Krajcik, 2021).

Performance-based assessments (including formative diagnostic and summative assessments) that use constructed-response items present unique challenges when it comes to scoring. These items generate a great variety of student responses, which cannot be graded with simple rubrics. The lack of clear-cut scoring criteria can lead to inconsistencies in scoring, affecting the reliability of results. Teachers need thorough training to perform this task—and even with such training, there is a high probability that they cannot do so quickly and accurately. Furthermore, the NGSS and A Framework for K–12 Science Education call for aligning three-dimensional performance-based assessments to relevant learning progressions to ensure targeted and effective feedback, which is essential for productive learning but can be very time-consuming and taxing for educators to grade (National Research Council, 2012). Learning progressions are considered a more sophisticated way of reasoning within a content domain. Students not only need to integrate three dimensions, but they must also probe their ability at various levels of sophistication in accordance with relevant learning progressions (National Research Council, 2012). This adds another layer of complexity in scoring and giving feedback for multidimensional performance-based assessments because both the score and the feedback should align to a specific learning progression level. Teachers must invest significantly more time to score three-dimensional, performance-based assessments if they are to support relevant student science knowledge and understanding. This feedback should guide the teacher and the student in deciding what additional support is needed to help the student move to higher learning progression levels. Immediate, accurate feedback is especially critical for teachers to make instructional decisions that improve three-dimensional learning among diverse students (National Academies of Sciences, Engineering, and Medicine, 2017).

NGSS-aligned, three-dimensional, performance-based assessment results provide essential insights into students' deep understanding of science concepts, multidimensional reasoning, creative thinking, and problem solving (National Research Council, 2014). These assessments also enable educators to bridge patterns of inequity and accurately evaluate a diverse range of students (Alozie et al., 2018). In our work, we strive to promote agency among teachers and students by creating equitable, instructionally supportive assessment systems. These systems empower teachers with tools to make data-driven instructional decisions and support students in taking ownership of their learning. By recognizing, identifying, and addressing systemic biases in human scoring, particularly in constructed responses, fairness and effectiveness of educational assessments can be enhanced.

1.2. Purpose and Significance

The purpose of this study was to explore the capabilities of an artificial intelligence machine learning system (AI-MLS) for scoring upper elementary students' constructed responses on multidimensional performance-based science assessments. Specifically, we sought to determine how accurately the AI-MLS could replicate human scoring while maintaining reliability and consistency. Additionally, we aimed to investigate the potential of the AI-MLS to promote educational equity by reducing teacher workload and minimizing biases in scoring. With this technology innovation, we aimed to meet the needs of all students, including those with specific learning disabilities, by providing a fast, accurate, unbiased, and cost-effective assessment scoring tool. This tool enables data-driven differentiated instruction, and thus empowers teachers to make informed instructional decisions, tailoring their teaching strategies to address the diverse learning needs of all their students effectively.

AI resources and tools are rapidly advancing, becoming essential to research and education in science and engineering (National Science Foundation, 2024). According to the National Artificial Intelligence Initiative Act of 2020, AI "has the potential to change and possibly transform every sector of the United States economy and society" (Johnson, 2020) and "make life better for everyone" (White House Office of Science and Technology, 2022). However, researchers and practitioners lack a clear understanding of the capabilities of AI and its potential to affect social and economic sectors, including ethical concerns, national security implications, and workforce impact (Johnson, 2020).

New developments in AI-related educational assessment are attracting interest to improve assessment efficacy and validity, with particular attention to the analysis of the large amount of process data being captured from digital assessment contexts (Gardner et al., 2021). The National Artificial Intelligence Initiative Act of 2020 notes that academic researchers have limited access "to many high-quality datasets, computing resources, or real-world testing environments to design and deploy safe and trustworthy AI systems" (Johnson, 2020). This limitation directly impacts the education pipeline, which currently does not adequately support educators in meeting the demands of the next generation of students studying and using AI.

In a recent report, the U.S. Department of Education Office of Educational Technology (U. S. Department of Education, Office of Educational Technology, 2023) noted a sharp rise in interest and concern about AI. The report highlighted different ways that instructional technology innovators are adding AI-based capabilities to their systems. These applications can help educators with a variety of tasks, such as student data collection, classroom instruction, school logistics, student assessments, and parent–teacher communication. Teachers not only use AI-powered services in their everyday lives—for instance, as mapping tools, for shopping recommendations, and to write and correct text—but also in their profession to enhance learning. AI-based digital tools, such as speech recognition, text and essay generation, and image production, offer adaptations and personalization to boost student learning and to improve teacher professional development and classroom instruction.

For several years now, educators have used AI tools to score traditional recall-based answers (primarily multiple-choice items) on student formative and summative assessments. These tools offer real-time, individualized feedback to help teachers meet each student's learning needs. Educators can address individual needs efficiently and effectively, and students are empowered to "own" their learning process (Chen, 2023). AI reduces the subjective bias associated with human grading, streamlines the scoring of recall-based items, and provides quick access to assessment results so that teachers can make immediate, data-driven instructional decisions to differentiate and improve student learning (Nehm et al., 2012). Unfortunately, these tools have rarely been used to score student assessments that go beyond memorized information—such as science performance assessments with constructed-response items to capture the three-dimensional nature of science learning. The use of AI and machine learning technology to score these assessments is an innovation that holds promise for effective, accurate, and unbiased grading with timely feedback for teachers and students.

To function optimally, an assessment system requires a variety of measurement approaches and multiple scoring strategies, with evidence to support educational decision-making across all levels of the learning system (National Research Council, 2006). Assessments and scoring must link tightly to curriculum, instruction, and professional learning so that each element is built with a shared vision of student learning goals (National Research Council, 2014; National Research Council, 2006; NGSS Lead States, 2013).

Diverse students bring a vast range of experiences, background knowledge, and abilities to the classroom. Assessments serve as a primary feedback mechanism in a coherent learning system, helping teachers make instructional decisions, holding schools accountable for meeting learning goals, and monitoring program effectiveness (National Research Council, 2006).

Differentiated instruction is a powerful approach that helps teachers address the diverse learning needs of students, including those with specific learning disabilities. To provide effective differentiated instruction, teachers must know their students well, with a full understanding of individual learning styles, preferences, and needs. Most importantly, teachers must know their students' current levels of academic achievement in all subject areas, and be prepared to provide appropriate content, processes, products, and environmental differentiation. While the implementation of differentiated instruction also depends on economic and human resources to meet individual education needs, tools like the AI-MLS can play a critical role in guiding the effective allocation and management of these resources. By providing consistent, data-driven insights into students' current levels of academic achievement and patterns in their responses, the AI-MLS equips educators with actionable information to inform instructional decisions. This enables teachers to target their efforts more effectively, tailoring content, processes, products, and environmental differentiation to the specific needs of their students.

Rather than replacing human judgment, AI tools serve as complementary resources that enhance teachers' ability to create inclusive learning environments. By identifying trends and learning gaps, these tools provide the guidance necessary to optimize instructional strategies and ensure that economic and human resources are directed where they are most needed. This integration of AI into differentiated instruction supports the broader goal of fostering equitable educational opportunities for all students, particularly those with specific learning disabilities.

By exploring the capabilities of an AI-MLS for scoring three-dimensional assessments, we aim to empower teachers to deliver data-driven differentiated instruction, thereby addressing individual learning needs more effectively. Our research not only contributes to the immediate improvement of assessment practices, but also lays the groundwork for future advancements in AI applications within education.

1.3. Current State of Research

If a computer can be "taught" the content that students are required to know and can ask questions for which it has "learned" the answers, it can assess students on their knowledge (Farra et al., 2015). And if, in a more sophisticated step, a computer can learn which quality criteria apply to a student's understanding and application of that knowledge relative to an assessment task, whether written or verbal, and can learn how to identify these criteria in student responses, it can assess the quality of the work. The capabilities of AI-MLS scoring in educational settings extend beyond simple knowledge assessment. Researchers developed an advanced essay scoring system to evaluate the persuasiveness of the opinions expressed and the relevance of the topic discussed within an essay (Farra et al., 2015). Their system assessed sentiment and argument strength, using features extracted from opinions, topics, and opinion–target pairs. This refined approach was tested on 58,000 essays from Test of English as a Foreign Language (TOEFL) applicants, which included 19 different prompts and contributions from non-native English-speaking undergraduate and graduate students. Results showed that predictions based on opinions and topics were positively correlated with human scores. Combining opinions with their targets produced the best correlation for all learners, with the opinion–target system performing and achieving the best Quadratic Weighted Kappa (QWK) scores. This nuanced capability of AI-MLS scoring ensures that the distinction between possessing knowledge and being able to understand and apply it is maintained, even amid the challenges posed by scoring three-dimensional, performance-based assessments. As noted by Gardner et al. (2021), the effective use of computers in these complex scoring tasks preserves the integrity of educational assessments, enabling a deeper analysis of student understanding and application skills.

AI technology, including machine learning approaches, has been used to score short constructed responses in assessments across various STEM disciplines and student levels, with reliability approximating human scoring (S. Zhai et al., 2020). Because of the lack of review studies on machine learning, S. Zhai et al. (2020) conducted a systematic literature review to address gaps in the current usage of applying machine learning in assessment by examining specific fundamental concerns related to machine learning. These concerns were as follows: How to apply the technology? How to ensure the accuracy of machine predictions? How to identify the pedagogical benefits that could be gained by using machine learning-based science assessments? The authors used a triangulation framework that examined the technological aspects, validity, and pedagogical features to address these concerns. Their findings on the technological aspects included articles on supervised machine learning, unsupervised machine learning, and semi-supervised machine learning. Through supervised machine learning, the machine must first learn from the data before making any decisions. Unsupervised machine learning does not learn from the data, but instead detects patterns from the data to decrease the effort needed by humans. Semi-supervised machine learning examines labeled and unlabeled data to find patterns in the unlabeled data. For the assessment and validity of comparing machine learning scores to human expert scores, the identified articles included self-validation, split validation, and cross-validation. Through their review, S. Zhai et al. (2020) noted that most articles concentrated on the accuracy and reliability of machine learning as well as cross-validation scoring. From the pedagogical aspect, their findings show promise for supporting students through adaptive and responsive learning. From this research, the authors identified a limited number of studies focused on K–12 science instruction, but machine learning improved the automaticity of examining and scoring complex constructs. Overall, machine learning using cross-validation achieved significant computer–human agreement.

Building on these foundational approaches, X. Zhai (2024) offers a comprehensive framework for the integration of AI and machine learning into science assessments, particularly for three-dimensional assessments aligned with the NGSS framework. In this chapter, the author discusses the development of AI systems capable of scoring constructed responses by using natural language processing and machine learning algorithms, emphasizing their ability to replicate human scoring patterns while reducing subjectivity and variability. The chapter highlights how AI tools can provide scalable solutions for assessing large datasets, enabling quicker feedback for educators, and supporting data-driven instructional strategies. The discussion also emphasizes the complexities of capturing nuanced student reasoning and ensuring equitable scoring practices while proposing systematic solutions to address these challenges. Additionally, X. Zhai (2024) addresses the challenges and ethical considerations of implementing AI in educational assessments, including algorithmic fairness, transparency, and the risk of amplifying systemic biases. Key recommendations include prioritizing validity and scalability in the development of AI-based assessments and leveraging these tools to provide actionable, personalized feedback to both educators and students. This chapter contributes to a growing body of literature that underscores the transformative potential of AI and ML in creating assessments that are not only efficient but also aligned with modern educational priorities, such as equity and personalized learning. X. Zhai's (2024) work aligns closely with the objectives of the present study, as it explores the broader implications of AI integration for educational policy, emphasizing its potential to create data-driven, equitable, and responsive teaching practices.

Nehm et al. (2012) showed that AI-based text scoring could be used to identify key ideas in college students' short, written evolutionary explanations. They began by using the Summarization Integrated Development Environment machine learning tool to score written explanations in biology. Their overall goal was to replace human scorers with scoring models built using machine learning. They compared machine learning scores to human expert scores using student responses on the Evolutionary Gain and Loss Test versions F and P. They created a set of features for each explanation, and then identified whether the text included the key concepts. They used four different conditions to analyze the human-generated scores. The sample included 2260 written explanations from 565 undergraduate students, all collected using an online response system. Student responses were graded by two expert human raters who had a background in biology. The authors found that the machine learning system exceeded the Kappa performance benchmark within each instrument for key concepts.

Jescovitch et al. (2020) obtained reasonable accuracy in comparing different coding approaches and machine learning applications to the learning progressions of college students. They started by comparing a holistic approach based on learning progression levels and a dichotomous, analytic approach of multiple concepts, or bins, of student reasoning. They analyzed four constructed-response assessment items and used specific criteria for the selection of the four items used in their study, which were distributed to undergraduate students through online homework or bonus assignments in their physiology courses. A total of 700 student responses were randomly selected for rubric development. Once the two rubrics were developed and approved by the two experts, the rubrics were used for human coding. Two experts used both holistic and analytic rubrics. Once the consensus coding was completed, the data were used to train the supervised machine learning models. The human-coded data were used to train two machine learning models—an eight-classification algorithm ensemble implemented in R, or the constructed response classifier, and a single classification algorithm implemented in the LightSide, GPL version 3, researchers' workbench. For human–computer inter-rater reliability, results for the constructed-response classifier machine learning model scored between 0.60 and 0.70 for the holistic approach, while the analytic model ranged from 0.65 to 0.74. For LightSide, the holistic approach data ranged from 0.59 to 0.69, while the analytic approach ranged from 0.66 to 0.69. Holistic and analytic coding approaches both achieved acceptable levels of agreement from human coders and machine learning models.

In Maestrales et al. (2021), machine learning applications to score several three-dimensional and constructed-response assessment items for high school chemistry and physics provided good agreement with human scores. While most studies have used a single algorithm to score assessments, this study used the Automated Analysis of Constructed Responses, which can automatically score students' responses with more than one algorithm. The researchers used the Crafting Engaging Science Environments database with 6700 high school students' responses. Four constructed-response tests were developed and then scored in a two-cycle process. In the first cycle, the raters were trained and then practiced scoring. If the inter-rater reliability was low, the rater continued training. While some challenges arose for human raters due to disagreements about rubrics, the authors were able to address these challenges by making the rubrics more specific around the dimensions they were measuring. In cycle two, the human scores and students' responses were used to develop training sets for the algorithmic models as they were then given to the Automated Analysis of Constructed Responses system. Human raters achieved good inter-rater reliability for two items and good reliability for the rest. Machine–human agreement was higher than human–human agreement. Accuracy ranged from 28% to 93% for the individual proficiency levels used. The machine scored greater than 59% in all categories. There was high overall agreement between computers and humans scoring constructed-response items, demonstrating that machines can accurately score student-constructed responses.

Tansomboon et al. (2017) identified different forms of automated guidance to help students obtain a deeper understanding of science content and make successful revisions to their science explanations. The authors conducted two studies in sixth-grade science classes comparing transparent guidance to typical guidance, along with comparing strategies for promoting knowledge integration, revisiting guidance, and planning guidance using a natural language processing tool called c-rater ML TM, which works by building a model using a series of NLP steps based on human scoring of at least 1000 student responses on an item. The first study compared transparent to typical guidance, using the Web-based Inquiry Science Environment curriculum. Results showed that the transparent condition scored higher than the adaptive condition. For students who began with low prior knowledge, the transparent condition led to greater understanding. This result indicated that the use of automated guidance can aid in personalizing instruction and increase motivation and learning. The second study examined the influence of revisit guidance compared to writing guidance for knowledge integration. This study used the curriculum unit on thermodynamics, as in the first study, and each student was randomly assigned to one of the two conditions. Results showed that both revisiting and planning guidance motivated students to revise their written explanations, giving students specific instructions and guiding students to act on those suggestions. These findings illustrate the potential of AI-MLS to enhance educational outcomes by not only assessing knowledge, but also directly influencing the learning process. Such systems provide dynamic, personalized feedback that can adapt to individual student needs, thereby improving the accuracy and the educational impact of performance-based assessments.

Another study (Lee et al., 2019) used an automated test scoring system that provided real-time feedback designed to help students revise their scientific arguments. The system produced gains in student scores from pretest to posttest. The researchers examined responses from a water module implemented with 935 students taught by 15 teachers. The project included two human experts who scored the students' responses. Human–human agreement ranged from 0.86 to 0.96 in QWK values. Human-generated scores of open-ended students' responses were used to create automated scoring models via c-rater machine learning. With c-rater machine learning, the QWK values for human–machine agreement were greater than 0.70. The scoring system included two feedback functions: the diagnostic function, which showed the score the student received; and the suggestive function, which showed how students could improve their score. Overall, students used the automated scoring system to make more revisions in the tasks that involved models.

These advances have been made mostly at high school and college levels. No comparable work has been published to date at the upper elementary school level, despite potential benefits for this population. As a group, upper elementary school teachers in general education classrooms lack science training and are less knowledgeable about NGSS three-dimensional performance-based assessments and learning progressions. They are less able to reliably and accurately score constructed responses, and have very limited time for this laborious task.

1.4. Aim and Main Conclusions

The main aim of this paper is to describe the development and preliminary results of our AI-MLS scoring model for upper elementary students' constructed responses on science assessments. The research team began exploring the development of this system after encountering the challenge of scoring thousands of constructed responses from multidimensional performance-based assessments during a pilot study. The pilot study evaluated the effects of our Effective Science Curriculum for Online Learning and Academic Results (ESCOLAR) program on upper elementary students' ability to engage with complex scientific concepts, improve their scientific practices, and enhance their understanding of science. To evaluate the curriculum, we used three-dimensional, performance-based assessments adapted from The Wonder of Science.

After being trained with 300 human-scored responses, the AI-MLS scored an additional set of 141 responses, achieving a QWK value of 0.72. This value indicates that the model had substantial capability to score student responses based on the human grading it had learned from. When machine scores were compared to human scores, and disagreements were evaluated, it was determined that sometimes the AI-MLS score was correct rather than the human score. This finding underscores the potential of AI-MLS to reduce human bias and enhance the accuracy of performance-based assessment scoring.

The AI-MLS model developed in this study demonstrated substantial potential as a tool for enhancing science education through accurate and efficient performance-based assessment scoring. This innovation could be used to support teachers in delivering data-driven differentiated instruction, ultimately fostering a deeper understanding of science concepts and practices among upper elementary students.

2. Materials and Methods

2.1. Development of the AI Scoring Tool

The development of the AI-MLS model for scoring students' constructed responses was driven by the need for an efficient, accurate, and scalable tool to score multidimensional performance-based assessments. LightSide, a well-established machine learning framework designed specifically for text classification, was selected as the core tool for developing the model due to its flexibility and ease of use for educational data tasks (Mayfield et al., 2014; Mayfield & Rosé, 2013).

2.1.1. Architecture

The architecture of the AI model summarized in Table 1 includes feature extraction and data representation, model training, and model evaluation.

Table 1. Architecture of the AI model.

Feature Extraction and Data Representation	Model Training	Model Evaluation
Input Data Data used to train the AI-MLS model consisted of human-scored constructed responses, which were formatted in a CSV file. Each row in the file represented a training example, with columns indicating the student's text response and the corresponding human-assigned score. This structured representation, compatible with common spreadsheet software, facilitated the loading of large datasets into LightSide. Feature Extraction LightSide's feature extraction capabilities were employed with the "Basic Features" extractor, which implements a bag-of-words approach. This technique, while simple, allows for effective text classification by treating each word in a student's response as a discrete feature. To capture more nuanced text patterns, advanced techniques such as n-grams (unigrams, bigrams, and trigrams) and part-of-speech tagging were explored. n-grams help capture word sequences, improving the model's ability to interpret more complex sentence structures, while part-of-speech tagging helps the model differentiate between types of words (e.g., nouns, verbs, adjectives) for improved accuracy in natural language processing tasks (National Research Council, 2006; Maestrales et al., 2021).	Training Data The model was initially trained using a dataset comprising 250 human-scored constructed responses. Training on human-scored responses allowed the model to learn complex patterns and decision criteria that human raters use, making it capable of replicating human grading practices. Studies show that machine learning models trained on similar datasets achieve human-level accuracy in educational assessments, particularly in science and mathematics (Gardner et al., 2021). Algorithm Selection Logistic regression was chosen as the primary classification algorithm due to its effectiveness in natural language processing tasks, including text classification. Logistic regression is widely recognized for its ability to model the probability of a response falling into a particular category and performs well in high-dimensional data spaces typical of natural language processing applications (Chen, 2023). Its interpretable nature makes it a valuable choice for applications requiring transparency in how scores are assigned (S. Zhai et al., 2020). Cross-Validation To ensure the model's generalizability, 10-fold cross-validation was employed. Cross-validation divides the dataset into 10 subsets, using 9 subsets to train the model and 1 subset for testing. This process is repeated 10 times, with each subset serving as a test set once. Cross-validation provides a robust method for estimating model performance, reducing the risk of overfitting and ensuring that the model can generalize to new data (Nehm et al., 2012).	Performance Metrics The QWK statistic was used to evaluate the model's performance. This metric measures agreement between AI-generated scores and human-assigned scores, while accounting for the possibility of chance agreement. A QWK value of 0.72 was achieved, indicating substantial agreement between the AI-MLS model and human scorers, validating the model's reliability and accuracy in scoring multidimensional assessments.

2.1.2. Data Used for Training and Testing the Model

Data used for training and testing the AI model are described in Table 2.

Table 2. Training and testing data for the AI model.

Training Data	Testing Data
The AI-MLS model was first used to test one constructed-response item of the Home Run 4th-grade energy unit multidimensional performance-based assessment, containing 441 student responses. Then, the model was repeated with four more items from the same test. The dataset comprised 300 constructed responses scored by humans. Each response was labeled according to a rubric aligned with NGSS performance-based assessment criteria. The labels reflected varying levels of student understanding and application of scientific concepts.	After training, the AI-MLS model was tested on the remaining 141 responses, which were not part of the training dataset. This approach ensured that the model's performance was evaluated on an unbiased dataset, providing an accurate measure of its real-world applicability in educational settings. The model's scores were compared to human scores using performance metrics, such as the QWK, to document reliability.

2.1.3. Process in LightSide

The steps of the LightSide process are illustrated in Figure 1.

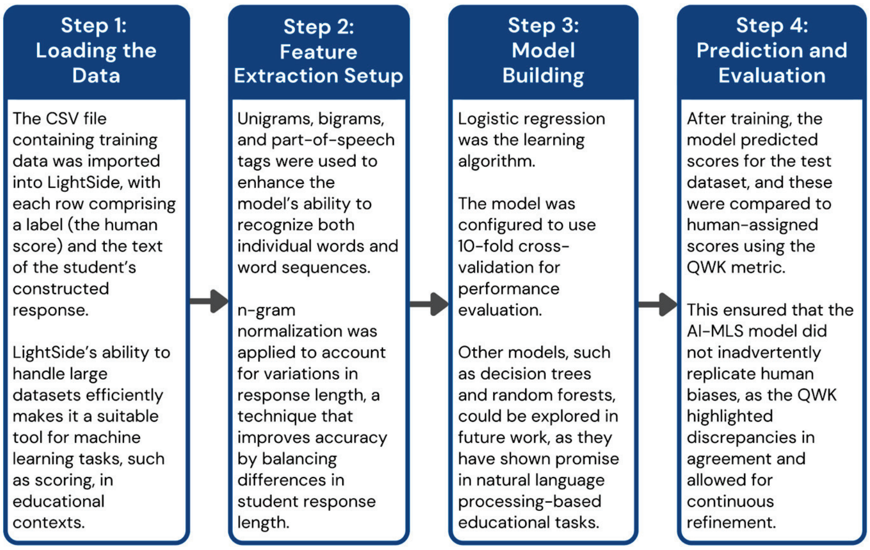

Figure 1. The LightSide process involved four steps: (1) loading the data, (2) feature extraction setup, (3) model building, and (4) prediction and evaluation.

2.2. Ethical Considerations

This study adhered to strict ethical standards throughout its design and implementation to ensure the protection of all participants. Informed consent was obtained from all students and, where applicable, their parents/guardians before data collection began. The project was approved by the University of Oregon Institutional Review Board, which assessed the research protocol for compliance with federal regulations and ethical guidelines related to human subjects research.

Additionally, ethical considerations specific to the use of AI in educational settings were carefully addressed. The use of AI in scoring student work introduces specific challenges, including the need to ensure transparency in how scores are generated, fairness in grading, and avoidance of biases embedded in the algorithms. AI systems used in educational contexts must be rigorously tested to avoid perpetuating systemic biases that could unfairly impact students based on factors such as race, gender, and socioeconomic background.

To ensure fairness in scoring practices, human raters received randomized responses from all demographic groups as well as pre- and posttest responses. This approach prevents raters from unintentionally scoring posttest responses higher than pretest responses or favoring one group over another. The randomization step complements the de-identification process, which ensures that raters cannot link specific responses to individual students or groups. By combining these measures, we mitigated the risks of both implicit and explicit bias during the scoring process.

To further address ethical considerations, the AI-MLS model was subjected to thorough validation procedures, which ensured that its predictions were accurate and equitable across diverse student populations. The research team also implemented procedures to continuously monitor the model's performance, so that any potential bias would be detected and addressed promptly. Only anonymized and de-identified data were used for model training and testing phases to protect participant privacy.

Because this was a novel application of AI technology in scoring complex, multidimensional performance-based assessments, the research team was committed to open communication with educational stakeholders. This included providing transparent explanations of the AI model's functioning to teachers, administrators, and policymakers to build trust and ensure the responsible use of AI in the classroom.

In summary, this study not only adhered to standard ethical practices, but also took additional steps to promote fairness, transparency, and accountability in the deployment of AI technology for educational purposes.

3. Results

3.1. Performance of the AI Scoring Tool

3.1.1. Initial Training and Testing Results

The model was trained using 300 human-scored responses. These responses reflected diverse levels of student understanding, captured through a rubric aligned with NGSS performance-based assessment standards. After the model was trained, it was tested on a set of 141 student-constructed responses. The average difference between AI-MLS and human scoring was minimal.

The initial QWK score of 0.72 indicates substantial agreement between human and AI-MLS scorers, surpassing the accepted minimum threshold of 0.60 for significant agreement in educational settings (Landis & Koch, 1977). This result shows that the AI-MLS model successfully replicated human decision-making.

The QWK value of 0.72 was automatically calculated by the LightSide machine learning software. This metric, embedded within LightSide's evaluation framework, compares observed agreement between AI-MLS and human scores with expected agreement by chance, applying quadratic weights to assess the magnitude of disagreement. The software uses standardized algorithms, such as the Fleiss–Cohen quadratic weighting scheme, to compute this value directly from the training and testing data.

The QWK calculation process in LightSide ensures a consistent and automated validation of the model's performance, removing the potential for user error in manual calculations.

3.1.2. Extended Evaluation on the Home Run Unit

After initial training and testing, the AI-MLS model was further evaluated using the Home Run unit multidimensional performance-based assessment. This unit included 441 student-constructed responses, scored by both the AI-MLS model and human raters. The AI-MLS model was then applied to additional constructed-response items from the same assessment to ensure consistency and reliability.

Results showed that the AI-MLS model maintained a high level of accuracy across different sets of constructed responses. QWK values remained consistently above 0.70, validating the tool's reliability in scoring diverse student responses.

3.1.3. Accuracy and Reliability of the AI Tool in Scoring Constructed Responses

The AI-MLS tool demonstrated a high degree of accuracy and reliability when scoring constructed responses, based on the QWK metric. The QWK value of 0.72 achieved during initial testing is a testament to the AI-MLS tool's capacity to accurately mimic human decision-making in assessing multidimensional performance-based assessments.

The QWK metric was chosen because it accounts not only for the possibility of agreement occurring by chance, but also for the magnitude of disagreement between scores. Unlike simple percentage agreement measures, the QWK statistic is particularly suited for educational assessments in which students receive partial credit for nuanced responses. This makes the metric ideal for measuring the performance of AI systems on assessments that involve complex student reasoning and responses. According to Landis and Koch's (Landis & Koch, 1977) benchmarks for interpreting Kappa values, the score achieved by the AI-MLS is classified as "substantial" agreement.

The reliability of the AI-MLS tool was further illustrated by comparing the QWK values for AI-MLS versus human scoring to inter-rater reliability among human raters. Human raters typically achieved QWK values between 0.60 and 0.75, which aligns closely with the AI-MLS's score of 0.72. An important advantage of AI-based scoring lies in its capacity to eliminate variability caused by subjective human interpretations, fatigue, or personal bias. For education professionals, this reliability means that AI-MLS provides consistent and unbiased assessment data that can serve as a foundation for making evidence-based instructional decisions. Importantly, the AI-MLS is not intended to replace professional judgment but rather to complement it by offering detailed, objective insights. Educators can use the scoring outputs as a diagnostic tool to identify patterns in student performance, recognize areas for targeted intervention, and tailor instructional strategies to the needs of individual learners or groups. This dual role of AI-MLS—as both a scoring tool and an instructional support resource—positions it as an asset for promoting equitable teaching practices and improving learning outcomes.

Breakdowns of the AI-MLS model's performance by specific rubric categories revealed that the AI tool achieved higher levels of accuracy when scoring mid-range responses (e.g., rubric scores of 2 and 3). While slight discrepancies were observed in extreme cases (i.e., scores of 1 or 4), further analysis showed that these differences were typically attributed to individual human scorers' biases or inconsistencies in rubric interpretation. By contrast, the AI-MLS consistently applied the same rubric criteria across all responses, reducing variability and enhancing fairness.

In addition to the QWK statistic, 95% confidence intervals were calculated for the AI-MLS scores compared to human raters. The intervals demonstrated overlap across all levels of the rubric, further validating the reliability of the tool. Confidence intervals around the QWK score also suggested that the variance between human and AI-MLS scores was minimal, increasing confidence in the robustness of the model.

Another critical aspect of the AI-MLS tool's reliability is its ability to reduce human bias in scoring. Even well-trained human scorers can introduce variability due to fatigue, subjective interpretation, or familiarity with specific students. In contrast, the AI-MLS tool applies objective criteria uniformly across all student responses, which significantly enhances the fairness and impartiality of the scoring process. This consistency is especially important in high-stakes educational assessments, for which fairness is paramount.

Further analysis of discrepancies between AI-MLS and human scores identified a small percentage of responses for which the AI model assigned a score slightly lower or higher than human raters. In most cases, these discrepancies were due to the AI system's rigorous adherence to specific rubric criteria, which occasionally diverged from the subjective leniency or stringency of human raters. These findings underscore the need for continuous refinement of the model, particularly in areas where complex conceptual understanding is required. Future work should integrate more sophisticated natural language processing techniques to enhance the model's capacity to capture subtle nuances in student reasoning.

3.1.4. Statistical Analysis of Agreement Levels

The AI-MLS model achieved a QWK value of 0.72 compared to human scorers, indicating substantial agreement. In contrast, inter-rater reliability among human scorers, measured by the same QWK metric, ranged from 0.60 to 0.75. These findings suggest that the AI-MLS model is not only comparable to human scorers in terms of accuracy, but also provides a consistent and unbiased scoring mechanism.

The QWK value, as calculated by the LightSide machine learning framework, provided a robust measure of agreement between AI-MLS and human scores. The LightSide software automates this calculation by analyzing the distribution of observed and expected scores across rubric categories, and applying quadratic weights to the differences. This automated approach ensures the standardization of results and minimizes potential bias in the statistical analysis.

The automated QWK calculation process within LightSide serves as an integral validation tool for AI models, allowing for efficient and accurate evaluation of scoring reliability. By achieving a QWK value of 0.72, the AI-MLS demonstrated substantial agreement with human scoring, underscoring its potential as a reliable and unbiased assessment tool.

3.2. Overall Findings and Implications for Educational Practice

3.2.1. Overall Findings

The AI-MLS model achieved substantial agreement with human raters, maintaining QWK values above the accepted benchmark across different assessment tasks. The reliability of the AI-MLS model, particularly in scoring middle-range responses, highlights its capacity to replicate human decision-making patterns with notable consistency. For education professionals, the AI-MLS offers a streamlined, scalable solution for scoring constructed-response assessments, reducing the time burden traditionally associated with these tasks. Beyond efficiency, the tool's consistent application of rubric criteria enhances the quality and reliability of assessment data, providing educators with actionable insights. These insights can inform differentiated instruction, helping teachers address specific learning gaps or challenges faced by individual students. By shifting the focus from scoring to data-driven decision-making, the AI-MLS tool enables education professionals to improve classroom practices and promote equitable learning outcomes.

3.2.2. Implications for Educational Practice

Detailed analysis of the AI-MLS performance reveals a high level of accuracy in scoring, comparable to human raters. Given the scalability of AI scoring systems, the AI-MLS offers an effective option for assessing large-scale constructed-response assessments.

By leveraging the consistent and data-driven scoring provided by AI, educators can shift their focus from grading to teaching, using the timely feedback generated by the AI-MLS to tailor instruction for diverse learners. The ability of the AI-MLS to provide consistent and reliable feedback across multiple rubric levels shows its potential for contributing to equity in education by minimizing human bias in scoring. Additionally, education professionals can utilize these objective results to identify trends in student performance, align instructional strategies with learning needs, and foster a more inclusive classroom environment. By doing so, the tool supports equity in education by minimizing subjective biases while empowering educators with actionable data to address the diverse academic and cognitive needs of their students.

4. Discussion

4.1. Interpretation of Results

Results from this study provide insights into the performance and potential of an AI-MLS in scoring student-constructed responses. The substantial agreement between the AI-MLS model scores and human scores, indicated by a QWK value of 0.72, is evidence of the tool's reliability and accuracy. This finding aligns with existing research, such as that of S. Zhai et al. (2020) and Nehm et al. (2012), which demonstrated the efficacy of AI and machine learning in educational assessment tasks. The AI-MLS model's ability to replicate human scoring patterns with high accuracy indicates that it can serve as a valuable asset in educational settings, particularly in supporting teachers in the labor-intensive task of scoring multidimensional performance-based assessments.

The significance of the AI-MLS tool extends beyond simple automation by enhancing the reliability and fairness of assessments, particularly when paired with human validation. As demonstrated in this study comparing an AI-MLS model with traditional human scoring methods, the AI-MLS tool not only matches but, in some cases, exceeds the consistency and reliability of human scorers, a result also noted by Maestrales et al. (2021). AI tools reduce variability between different raters, ensuring consistency in applying rubric criteria, which is critical for promoting equity in education. This helps mitigate systemic biases in the classroom, where human scorers may introduce bias, fatigue, or subjectivity. Research has documented that human scoring can be influenced by factors such as implicit biases related to student demographics, rater fatigue, or even scorer mood (Brookhart, 1999; Knight & Cooper, 2019). AI-MLS scoring ensures that all students are evaluated solely on the merit of their work, preventing the unintentional favoring of certain student groups over others. By providing timely and precise feedback, the AI-MLS tool enables educators to make data-driven instructional decisions, supporting differentiated instruction and improving student outcomes. In this way, AI technology fosters more equitable and objective assessment practices that directly benefit both educators and students.

4.2. Enhancing Understanding Through AI-MLS Systems

AI-MLS tools provide educators with more than just an efficient means of scoring; they offer an opportunity to reshape classroom dynamics by fostering educational equity and teacher agency. Traditional assessment methods often disadvantage underrepresented students, such as those with specific learning disabilities or students from diverse linguistic backgrounds, by not adequately capturing their multidimensional understanding. The AI-MLS, by offering consistent and objective assessment scoring procedures, ensures that students' knowledge and reasoning skills are fairly measured, promoting inclusivity in the classroom.

For teachers, the AI-MLS model allows for the redirection of valuable time and resources from manual scoring to instructional strategies to enhance student learning. Teachers are freed from the repetitive task of grading, enabling them to engage more deeply with students, identify learning gaps, and personalize instruction. By providing timely feedback, AI-MLS scoring supports differentiated instruction—teachers can tailor their approaches to meet the needs of both struggling and advanced learners. This approach ultimately empowers educators, allowing them to exercise greater agency in their teaching, informed by data-driven insights into student performance. X. Zhai (2024) underscores the importance of ensuring that AI models are not only scalable but also capable of generalizing across diverse educational settings. These principles align with the need for teacher training and support to effectively leverage AI-generated data. The findings of this study demonstrate that the AI-MLS tool provides consistent scoring while addressing the complexities of multidimensional assessments. Future efforts should prioritize enhancing model adaptability across various contexts, ensuring that teachers in all environments can access equitable and actionable AI insights. However, to fully capitalize on the potential of AI-MLS tools, teacher training must be part of implementation. Teachers need professional development opportunities to become proficient in using AI-MLS-generated data to inform their instructional practices. This training should focus not only on the technical aspects of AI tools, but also on equipping teachers with strategies to effectively interpret and integrate AI-generated data into existing instructional practices. This approach ensures that AI tools complement teachers' ongoing professional development in pedagogy and subject-specific didactics, rather than requiring entirely new or separate pedagogical frameworks. By enhancing their ability to utilize AI insights, educators can better identify and address diverse student needs.

For students, the implications of AI-MLS scoring extend beyond simply being evaluated. The insights provided by the AI-MLS equip teachers with timely and accurate data, allowing them to personalize feedback and differentiate instruction based on each student's individual needs. While the AI-MLS we tested does not directly provide feedback to students, its ability to assess complex, multidimensional responses equips educators with the tools needed to engage students in meaningful discussions about their progress. This approach promotes a culture of continuous learning and revision, key aspects of student agency. Furthermore, the AI-MLS's focus on assessing constructed responses emphasizes critical thinking and problem-solving skills, aligning with educational reforms that prioritize knowledge application and higher-order thinking (Johnson, 2020).

While this study primarily focuses on the technical reliability of the AI-MLS tool and its utility for teachers, understanding how students perceive and respond to the feedback generated by AI-based systems is equally important. Student perspectives can provide insights into how feedback impacts their learning, motivation, and engagement, ultimately influencing their academic outcomes. As highlighted by (Hmelo-Silver et al., 2024), the value of feedback is significantly influenced by how students perceive and act upon it. Positive student perceptions can foster a growth mindset and promote better academic performance, while unclear or overly technical feedback may hinder progress. Future studies could explore how AI-MLS-generated feedback is received by students to optimize its effectiveness and alignment with student needs.

4.3. Broader Context

The capabilities of AI-MLS extend beyond mere scoring to encompass comprehensive educational evaluations that emphasize the quality and applicability of student knowledge. In line with previous research (Farra et al., 2015), the results of this study reinforce the importance of AI-MLS in recognizing nuances in student responses, such as argument strength, sentiment, and relevance, and their potential to mirror complex decisions made by human scorers. These insights, along with the demonstrated reliability of AI in capturing students' constructed responses, point toward a broader application of AI-MLS in addressing the challenges of multidimensional assessments in various educational settings.

The integration of AI-MLS tools in the classroom can serve as a vehicle for educational reform. As noted by the National Science Foundation (2024) and the National Artificial Intelligence Initiative Act (Johnson, 2020), AI has the potential to transform key sectors of society, including education. In the context of schooling, AI-MLS represents a pivotal shift toward more data-driven, equitable, and responsive teaching practices. The consistency and objectivity offered by AI can level the playing field for students who have been historically marginalized or disadvantaged by traditional forms of assessment.

In addition to fostering equity, AI can help shift the role of teachers in the classroom. By automating administrative tasks such as grading, teachers are empowered to focus on their primary role as facilitators of learning. This shift aligns with broader efforts in educational policy to enhance teacher agency—providing educators with the tools and autonomy to make informed decisions about how best to support their students. As AI tools evolve, they hold the potential to provide real-time insights that go beyond scoring, such as identifying patterns in student learning and suggesting targeted interventions.

4.4. Addressing Challenges and Opportunities in AI Integration

Despite the evident benefits of AI-MLS, there are challenges in integrating AI into educational settings. One major consideration is the training and professional development required to ensure that teachers can effectively utilize AI tools. The successful deployment of AI-MLS models depends not only on the robustness of the technology, but also on the capacity of teachers to interpret and act on the data generated. As S. Zhai et al. (2020) note, the pedagogical benefits of AI are maximized when educators are equipped to understand and apply the insights provided by these systems.

Incorporating AI training into teacher preparation programs is essential. This will help future educators develop the skills to navigate AI-generated insights, integrate data-driven teaching practices, and apply differentiated instructional strategies. By embedding AI training into certification and professional development programs, educators will be better prepared to harness the full potential of AI-MLS in the classroom.

Additionally, the ethical implications of AI in education, particularly regarding data privacy and algorithmic transparency, need careful consideration. To address these concerns, AI systems must be developed with safeguards that protect student data and ensure fairness in their use. Without these measures, there is a risk that AI could unintentionally perpetuate existing inequalities or introduce new biases into the educational system.

In conclusion, AI-MLS represents a promising advancement in the way educators assess and support student learning. By enhancing the accuracy, objectivity, and timeliness of assessment, AI-MLS has the potential to reshape classroom dynamics, promoting educational equity and teacher agency. However, the full realization of these benefits depends on thoughtful implementation, professional development, and a commitment to addressing the ethical considerations of AI integration.

4.5. Limitations and Future Research

This study had several limitations. The training and testing of the AI-MLS model were based on a relatively small dataset of constructed responses within the domain of upper elementary science assessments. Although the model performed well, the relatively small sample size limits the generalizability of findings. Future research should involve larger, more diverse datasets that represent a wider range of student populations and varying educational contexts. This will provide more comprehensive validation of the accuracy and reliability of AI-MLS scoring across diverse environments.

There were occasional instances of disagreement between the AI-MLS model and human scorers, highlighting the need to investigate discrepancies. These divergences between AI and human scorers may stem from nuanced, subjective interpretations of open-ended responses. Understanding these discrepancies is critical for refining the AI algorithms and ensuring the system's capacity to handle the full complexity of student work. This could involve training the model on broader sets of human scores that include different scoring perspectives or revising rubrics to address more nuanced criteria.

Another key limitation lies in the scope of this study, which focused exclusively on upper elementary science assessments. Science education offers a unique opportunity to evaluate three-dimensional performance-based assessments, but application of the AI-MLS model to other subject areas, such as mathematics, language arts, and social studies, should be explored. Other subject areas may present distinct challenges for AI-based scoring. Extending the application of AI-MLS to these subjects and varying educational levels (e.g., middle and high schools) will offer valuable insights into the adaptability of AI-based scoring. Performance-based tasks vary significantly across subjects, which may require customized training models tailored to the specific demands of each discipline.

Future studies should explore scaling the AI-MLS to larger datasets that include a broader diversity of student populations. Increasing the size and variety of datasets will provide a more robust test of the model's accuracy and generalizability. Additionally, investigating the use of AI-MLS across different grade levels and subjects will demonstrate the model's flexibility. Understanding how the AI-based scoring system adapts to different types of assessments—such as those requiring more subjective or creative responses—will be important for expanding its applicability.

Future collaborations between AI developers and educators are essential for refining the scoring tool. By actively involving teachers in the development process, AI tools can be better aligned with classroom realities and the diverse needs of students. Educators can provide valuable insights into how AI systems should be adapted for classroom use, ensuring that the tools perform well technically and support pedagogical goals. Collaborative efforts could focus on integrating AI-MLS with other educational technologies in order to create a comprehensive platform for supporting differentiated instruction and personalized learning.

Another area for future research is the adaptability of AI-MLS across different educational settings and classrooms. The extent to which AI-MLS can be easily integrated into varied instructional environments, particularly in schools with limited technological infrastructure, remains unknown. The successful implementation of AI-based scoring systems, such as AI-MLS, relies on adequate infrastructure and training. It is vital to explore how AI tools perform across schools with differing access to technology, resources, and professional development opportunities. For under-resourced schools, these requirements highlight the broader need for systemic investment in equitable educational resources. Ensuring access to such tools across diverse educational settings is crucial for maximizing their potential to improve teaching and learning outcomes. The present study did not address the impacts of AI-based scoring on teacher practice and student outcomes. Understanding how such tools influence instructional decision-making is crucial. Future research should examine how teachers use AI-MLS-generated data to inform their teaching strategies, tailor instruction, and engage students. Additionally, it is important to investigate how students respond to AI-assisted feedback, especially in terms of motivation, self-regulation, and agency in their learning process.

The ethical and privacy concerns associated with AI-driven educational tools deserve continued attention. Future research should evaluate how student data are handled to comply with privacy regulations and fairness in AI algorithms. Potential biases in AI systems, whether stemming from the training data or inherent in the algorithms, must be critically examined to ensure that AI technology does not reinforce existing inequities in education.

In conclusion, the AI-MLS model developed in this study shows promise in enhancing the reliability, fairness, and efficiency of educational assessments. Continued research is required to expand the scope of AI scoring models to additional subjects, larger datasets, and diverse classroom environments. Investigating the long-term implications for teaching practices, student engagement, and equity will ensure that AI tools are effectively integrated into educational systems for the benefit of all learners.

5. Conclusions

5.1. Summary of Key Findings

5.1.1. High Accuracy and Reliability

The AI-MLS model in this study demonstrated significant agreement with human scorers, achieving a QWK value of 0.72. This finding points to the potential for AI-MLS models to accurately replicate human scoring. AI-based scoring can minimize human error due to fatigue, bias, or subjectivity—and help ensure that students are evaluated fairly. Future iterations could further enhance accuracy by training the model on larger datasets that represent a broader range of student responses.

5.1.2. Consistency Across Assessments

One of the standout features of the AI-MLS model in this study is its consistent performance across different sets of constructed responses. The model maintained high QWK values, consistently above 0.70, which affirms its ability to accurately score student responses, even as the nature of those responses varies. This suggests that the AI-MLS model can handle diverse types of assessment items and levels of student ability, making it a flexible tool across various performance-based assessments. Exploring its application in different subject areas beyond science would offer further validation of its adaptability.

5.1.3. Comparative Effectiveness

The AI-MLS model not only matched but, in some cases, exceeded the consistency and reliability of human scorers. This comparative study highlights the potential of AI to mitigate the subjective elements of human grading, in line with prior research (Maestrales et al., 2021). The reduction in human bias and the enhanced objectivity offered by AI scoring tools are especially important in educational environments where equity is paramount. Future work should examine the impact of AI-based scoring on student outcomes and teacher practices.

5.1.4. Support for Differentiated Instruction

By providing timely and precise scoring results, the AI-MLS model offers a practical tool to support differentiated instruction. The data-driven insights generated by the model allow educators to quickly identify students' strengths and areas needing improvement, facilitating a personalized approach to learning. This real-time feedback empowers teachers to make informed instructional decisions, ensuring that both advanced and struggling learners receive the support they need to succeed. Over time, these data could contribute to broader educational trends, helping to personalize curricula and instructional strategies based on aggregated student performance data.

5.2. Final Thoughts on the Potential of AI in Education

The integration of AI in education presents significant opportunities for enhancing teaching and learning. AI tools like the AI-MLS model can revolutionize the assessment process by providing fast, accurate, and unbiased scoring of constructed responses. Unlike traditional human scoring, which research has shown can be affected by subjective interpretations, implicit biases, or fatigue (Brookhart, 1999; Knight & Cooper, 2019) AI scoring systems apply uniform criteria across all student responses. This not only eases the burden on teachers, but also ensures that students receive timely feedback that can inform their learning journey.

The use of AI in education can promote agency among both teachers and students. Teachers are empowered to make data-driven instructional decisions, while students receive individualized feedback that encourages them to take ownership of their learning. This dynamic fosters a more engaging and effective educational environment.

Beyond K–12 education, AI-driven tools like the AI-MLS model have far-reaching implications in lifelong learning and professional development. In these contexts, continuous feedback is essential for skills improvement, and the adaptability of AI assessment and scoring tools provides opportunities to support learners across different stages of their educational and professional journeys.

AI holds promise for addressing educational inequities by offering consistent evaluation tools to under-resourced schools. The scalable nature of AI systems can extend the reach of high-quality, unbiased assessment practices to underserved communities, ensuring a more level playing field for all students, regardless of location or available resources.

Looking ahead, the potential applications of AI in education extend beyond assessment alone. Intelligent tutoring systems, adaptive learning environments, and personalized learning pathways could transform the way students engage with educational content. By analyzing student data over time, AI has the potential to support the creation of individualized learning paths by providing insights into students' unique strengths and areas for growth. However, these paths must be developed and implemented under the supervision of educators, who bring essential pedagogical expertise and an understanding of students' cognitive processes. AI tools serve as aids to teachers, helping them identify and address student needs more efficiently. It is the teacher, with support from AI, who ultimately guides and refines the learning process to ensure it aligns with the student's cognitive and developmental context.

The successful integration of AI in education requires careful consideration of challenges, such as the need for adequate teacher training, data privacy concerns, and the potential for algorithmic bias. Addressing these challenges is crucial for maximizing the benefits of AI tools in educational settings and ensuring their ethical and equitable use.

In sum, the AI-MLS model developed in this study represents a promising advancement in educational assessment. By harnessing the power of AI, this tool can transform the way educators assess and support student learning, paving the way for a more personalized and effective educational experience. Continued research and development is essential for further enhancing the capabilities of AI in education and promoting its successful implementation across diverse educational contexts.

6. Patents

There are no patents resulting from the work reported in this manuscript.

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education sciences

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Article

Exploring Simulated Practice in Teacher Education: Opportunities to Professionalize the Teacher Role

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Abstract: In Norway, as in many other countries worldwide, student teachers often report a lack of coherence between their practice experiences and the teacher training provided on campus. For example, student teachers request more practice-relevant campus training on themes like parent–teacher conferences. Employers worldwide expect universities to prepare graduates to innovate practices. This empirical article addresses these challenges by engaging student teachers in simulation-based practice designs (SPDs), which include a class brief, group sessions with simulated parent–teacher conferences, and a debrief. The students are encouraged to act with agency and approach the simulated situations critically. Overall, this study shows that students are highly engaged and task-oriented across SPDs. The survey data (n = 39) show that students perceive the simulation experiences as relevant preparation for their future practice. Audio recordings (215 min) and field notes indicate that they are triggered to critically reflect on and generate ideas for addressing challenges in the simulated situations. There are instances of linking theory with practice, and even some "thinking outside the box". SPDs provide valuable opportunities to professionalize the teacher role but could benefit from more support and time to bridge the gap between theory and practice and encourage more innovative thinking.

Keywords: digital; simulation; teacher education; agency; professional development

1. Introduction

This study reports from a Norwegian state-funded research and development project launched to develop, strengthen, and systematize practical training in teacher education. This study aims to investigate the potential of innovating and implementing digital-simulation-based practice designs in teacher education to contribute to solving two recurring institutional challenges.

The first challenge, which is international (Jenset et al., 2018), concerns the separation between practice in schools and coursework on campus. In Norway, student teachers report feeling unprepared for their future teacher roles, often expressing a desire to learn more about parental cooperation and collaboration and conducting conversations with pupils and parents (Amundsen, 2021).

The second challenge is also applicable internationally. Worldwide, employers request graduated students with critical thinking skills, but universities struggle to sufficiently stimulate the development of such skills (Van Damm & Doris, 2022). Critical thinking can be defined differently, but it tends to be associated with, for example, observation, interpretation, analysis, evaluation, explanation, communication, and problem solving (see, e.g., Facione, 2011). Fundamental to critical thinking is agency—or the capacity of humans to act independently and make choices (Engeness, 2021). Agency in a teacher profession involves active and intentional actions done to try to make a significant difference (Toom et al., 2015). Further, critical thinking and agency tend to be nurtured through collaboration. Thoughts cannot think themselves but emerge through interaction between humans and mediating artifacts (Vygotsky, 1978, p. 50).

The above institutional and pressing challenges, related to how teacher education struggles to professionalize student teachers, call for action. Scholars have suggested investigating simulations as a means to engage students in more practical teacher training (Jenset et al., 2018; Hopwood et al., 2016), and we decided to develop what we have called digital 'simulated practice designs' (SPDs). Through such designs, we wanted to better prepare students for becoming schoolteachers, but also for improving how the schoolteacher role is enacted. Consequently, we started to simulate realistic school situations involving complex challenges. We also created tasks inviting student teachers to take an agentive approach and relate critically to the simulated situations.

In this article, we investigate the implementation of SPDs, where students have the chance to explore three different parent–teacher conversations through videos and a series of documents that frame these conversations. We implemented these SPDs in two classes in 2023 and two classes in 2024 and followed up with data collection.

Based on an analysis of a student survey with 39 responses (2023–2024), we answer the following research question:

To what extent do student teachers perceive the simulated practice experiences as relevant preparation for their future careers?

Further, we analyze audio recordings (215 min) from eight group sessions and field notes (2023–2024) to answer the following research question:

What characterizes the process of professionalizing when student teachers are exposed to simulated school practices?

With these questions, we explore both what the students themselves think about the professionalizing process we exposed them to and the characteristics of their enacted professionalizing process.

The university involved in this study calculates that the student teachers graduating in the next five years will teach 128,000 pupils during their careers. Thus, from a societal perspective, it matters that teacher education institutions manage to educate professional agentive teachers with the capacity to engage in critical thinking. The best strategy, then, is designing, monitoring, and redesigning the ways they are educated. This study is innovative in the sense that it involves designing and implementing SPDs to improve how students are prepared for a profession that is not fixed or stable but requires continuous development.

1.1. Lessons Learned from Previous Studies

In this project, we explore what we have called simulation-based practice design (SPD). Even if simulation-based learning (SBL) is often used in research, we stick to SPD because we want to focus on the professionalizing potentials of engaging with simulations—not as an alternative to school practice, but as a supplement. However, in searching for what to learn from others' studies, we have applied simulation-based learning (SBL).

The benefits of SBL are well documented. In a meta-analysis of 145 empirical studies on simulation-based learning environments in higher education, Chernikova et al. (2020) found that simulations are among the most effective means to facilitate learning complex skills across domains. The more authentic the simulation, the more relevant it is for learning. The use of technology and scaffolding relates to positive learning outcomes. Further, learners with limited prior knowledge of the topic being simulated benefit from examples and questions, while learners with more prior knowledge benefit more from reflection phases (Chernikova et al., 2020).

In teacher education, SBL can potentially bridge the gap between theory and practice (McGarr, 2020; Theelen et al., 2019). Further, a recurring finding in several studies is that SBL offers students an arena to try and fail in a safe setting (McGarr, 2020; Levin & Muchnik-Rozanov, 2022; Flavian & Levin, 2023; Manburg et al., 2017; Militello et al., 2021). SBL also promotes student active learning (Chernikova et al., 2020) and contributes to the development of student teachers' professional identity, confidence, and their ability to manage conflicts, challenges, and complex classroom situations (Chernikova et al., 2020; Dittrich et al., 2022; Flavian & Levin, 2023; Yablon et al., 2021). Collaboration and peer learning features are highlighted as benefits of SBL (Levin & Flavian, 2020), and the importance of reflection after working with the simulation is found to be significant (Mikeska et al., 2024). This aligns with other studies highlighting the importance of a debriefing phase as part of the SBL (Dittrich et al., 2022; Yablon et al., 2021).

The main focus of our study is parent–teacher conferences. This topic was also addressed in the project "Active professional development in a virtual world" (Faldet et al., 2021; Parish et al., 2024). In a flipped classroom practice using advanced virtual reality simulations, pre-service teachers practiced parent–teacher conferences, assuming the teacher role in dialog with a pupil and parent represented by avatars. Applying a Vygotskyan perspective on learning, Faldet et al. (2021) argued that VR simulation can be seen as a sociocultural approach to professional development for pre-service teachers since the professor in the simulation takes the role of "a more competent peer", including modeling behavior that the students can imitate (p. 76). Further, Parish et al. (2024) found that the VR simulation enhanced the students' self-efficacy through four key aspects: mastery experience, vicarious learning, receiving encouragement and feedback, and managing physiological and emotional states (p. 43).

The aforementioned studies employ different methodological approaches. Some are case studies based on qualitative interviews, quantitative surveys, and students' reflection logs (Militello et al., 2021; Sullivan et al., 2020; Manburg et al., 2017; Mikeska et al., 2024; Flavian & Levin, 2023; Levin & Muchnik-Rozanov, 2022; Levin & Flavian, 2020), while others involve design-based research (Thompson et al., 2019), action research (deNoyelles & Raider-Roth, 2015), and experimental studies (Yablon et al., 2021), in addition to meta-studies (Chernikova et al., 2020; Theelen et al., 2019). None of the simulation studies we found employed the same methodological approach as us, investigating the students' perceptions of the learning experience and qualitatively unfolding the professionalizing processes in which they engage.

It is also worth noticing that the literature reveals differences in how simulations are defined and designed. In some cases, simulations involve practicing with digital avatars, with or without VR (Dittrich et al., 2022; Faldet et al., 2021; Parish et al., 2024). In other cases, they are non-digital, involving interacting with actors in a furnished lab, or other forms of role play (Yablon et al., 2021; Levin & Flavian, 2020; Mikeska et al., 2024). Despite such differences, SBL tends to include mimics of real-world operations or situations in which learners are tasked to master specific techniques or solve complex problems. Learners are also engaged in reflective learning processes and practicing a role, relating to authentic situations with peers in low-risk, controlled environments.

In our study, we simulate school situations through videos and text documents, including intricate professional challenges and open-ended problems pertinent to the student teachers' future careers. The stories are carefully crafted and brought to life on a web page. This implies that, in addition to being an empirical contribution to the SBL field, we also offer an innovative contribution through the design, implementation, and investigation of new and flexible ways of simulating and making practice accessible in campus-based teacher training.

1.2. Design and Methods

This study builds on the LUDO project (a Norwegian abbreviation for "learning and education in a digital age"), but is part of the SIMPROF project (a Norwegian abbreviation for "simulated practice in teacher education: A new arena for professionalization") funded by the Directorate for Higher Education and Skills in Norway. SIMPROF is a design-based research project (Brown, 1992; Krange & Ludvigsen, 2009) where we as researchers collaborate with practitioners and professional video producers on the development of simulation resources that address needs expressed by student teachers. Subsequently, we collaborate with teacher educators on the implementation of these resources in a teacher education program offered at two campuses at a Norwegian University. During the implementation phase, we investigate how students use the resources and how they assess them. The insights are used in iterations. In this study, we report on the implementation and iterations of a specific simulation resource that focuses on parent–teacher conferences.

In the following, we first describe the simulation resource. Next, we clarify how this resource was implemented at various campuses with some variations. We then turn our attention to the collection and analysis of data, clarifying which types of data were collected where, and how we analyzed them.

1.2.1. The Simulation Resource

The simulation resource we focus on in this article is about parent–teacher conferences where pupils are also participating. To ensure authenticity, we created it over a 10-month period in collaboration with a school (including most of the teachers and their principal), teacher educators, educational researchers, a pedagogical psychologist, a media designer, a student teacher, and a professional movie maker. The resource consists of videos and various text documents contextualizing the videos, as well as a selection of task sets to guide students' engagement with the material. The student teachers are introduced to three seventh graders, presented in Figure 1, as well as their parents and teachers.

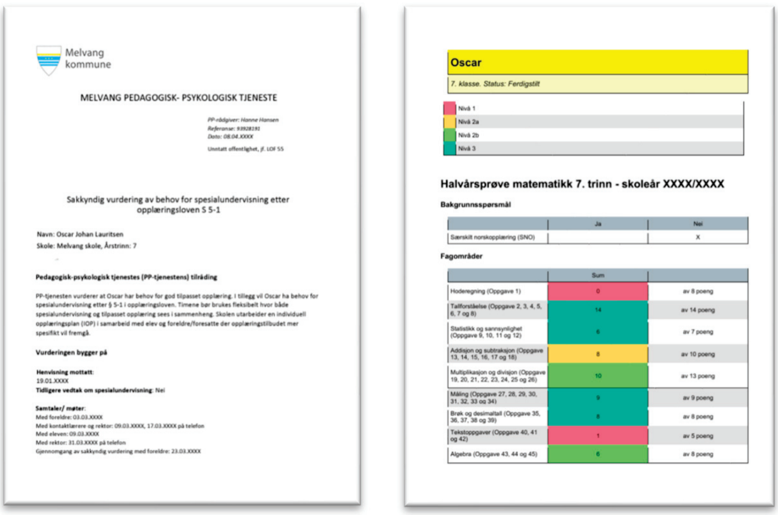
Figure 1. These are the three pupils the students get the chance to follow in videos and various text documents. To the left is Oscar, to the right is Maja, and below is Leander.

In Oscar's video, we see his mother meeting the teacher with very clear expectations and demands when it comes to following up Oscar's reading and writing difficulties. The teacher struggles in responding to these. We also observe Oscar, who is silent and mostly looks down when his mother is talking but starts to play the piano and talk with his teacher once his mother leaves the conference to take a phone call. Figure 2 shows screen shots from this conference.

Figure 2. This is Oscar and his mom. Oscar looks down, like he does most of the time during the conference. His mom just received a phone call from work, which she goes out to take in the middle of the conference.

In the video of Maja's parent–teacher conference, Maja is reading aloud from a text she has written to show some of her subject-specific competencies. However, our attention is drawn towards school challenges, where her absence, particularly in physical education, is addressed. Why? Could she have an eating disorder? Is Maja socially included or an "outsider" in the class? In the conference, the students get to know Maja but are still left with a series of unanswered questions. In the video involving Leander, the students see a seventh grader interested in the roleplaying game Dungeons and Dragons, which he plays with older friends. His mother is worried that he plays a lot, even at night. She questions Leander's well-being and addresses that he does not have friends in the class. The teacher replies that he seems safe, also referring to Leander's self-evaluation form. Instead of following up the mother's concern, she asks questions about Dungeons and Dragons. Leander's mother goes back to the classroom after the conference to say that she was unhappy with the teacher's lack of support.

In addition to the video clips, the student teachers gain access to 34 text documents that shed light on what can be observed in the videos. As mentioned, Oscar, for example, has just been tested for reading and writing disabilities, and the measures used by the pedagogical psychologists are among the documents that are important to understand his situation. In addition, the student teachers gain access to, for example, the teacher's email correspondence, reports, answers to assignments, and snippets from social media. Examples of such text documents are illustrated in Figure 3.



Melvang kommune

MELVANG PEDAGOGISK- PSYKOLOGISK TJENESTE

PP-rådgiver: Hanne Hansen
Referanse: 93928191
Dato: 08.04.XXXX
Unntatt offentlighet, jf. LOF 55

Sakkyndig vurdering av behov for spesialundervisning etter opplæringsloven S 5-1

Navn: Oscar Johan Lauritsen
Skole: Melvang skole, Årstrinn: 7

Pedagogisk-psykologisk tjenestes (PP-tjenestens) tilråding

PP-tjenesten vurderer at Oscar har behov for god tilpasset opplæring. I tillegg vil Oscar ha behov for spesialundervisning etter § 5-1 i opplæringsloven. Timene bør brukes fleksibelt hvor både spesialundervisning og tilpasset opplæring sees i sammenheng. Skolen utarbeider en individuell opplæringsplan (IOP) i samarbeid med elev og foreldre/foresatte der opplæringstilbudet mer spesifikt vil fremgå.

Vurderingen bygger på

Henvisning mottatt:
19.01.XXXX
Tidligere vedtak om spesialundervisning: Nei

Samtaler/ møter:
Med foreldre: 03.03.XXXX
Med kontaktlærere og rektor: 09.03.XXXX, 17.03.XXXX på telefon
Med eleven: 09.03.XXXX
Med rektor: 31.03.XXXX på telefon
Gjennomgang av sakkyndig vurdering med foreldre: 23.03.XXXX

Oscar
7. klasse. Status: Ferdigstilt

Nivå 1
Nivå 2a
Nivå 2b
Nivå 3

Halvårsprøve matematikk 7. trinn - skoleår XXXX/XXXX

Bakgrunnsspørsmål

	Ja	Nei
Særskilt norskopplæring (SNO)		X

Fagområder

	Sum	
Hoderegning (Oppgave 1)	0	av 8 poeng
Tallforståelse (Oppgave 2, 3, 4, 5, 6, 7 og 8)	14	av 14 poeng
Statistikk og sannsynlighet (Oppgave 9, 10, 11 og 12)	6	av 7 poeng
Addisjon og subtraksjon (Oppgave 13, 14, 15, 16, 17 og 18)	8	av 10 poeng
Multiplikasjon og divisjon (Oppgave 19, 20, 21, 22, 23, 24, 25 og 26)	10	av 13 poeng
Måling (Oppgave 27, 28, 29, 30, 31, 32, 33 og 34)	9	av 9 poeng
Brøk og desimaltall (Oppgave 35, 36, 37, 38 og 39)	8	av 8 poeng
Tekstoppgaver (Oppgave 40, 41 og 42)	1	av 5 poeng
Algebra (Oppgave 43, 44 og 45)	6	av 8 poeng

Figure 3. To the **left** is Oscar's report from the pedagogical psychological consultants, and to the **right** are his results on a math test.

While the simulation resource is designed to be flexibly integrated into diverse educational contexts, we have provided a total of four task sets, each organized as learning paths to support students in exploring specific issues. The tasks focus on the following overarching topics: dialog and interaction (task set 1), reading and writing difficulties (task set 2), and understanding the perspective of the pupil (task sets 3 and 4).

Task set 2, covering the topic "reading and writing difficulties", includes the following questions to prompt students' discussions:

> "To what extent and possibly how does the teacher succeed in achieving the national intention with parent–teacher conferences? What challenges arise in the conversation between Oscar, his mother, and the teacher? How would you describe the teacher's actions to solve these? The mother wants Oscar to be taken out of the class to help him with reading and writing, but we are unsure whether Oscar would like this himself. What are the pros and cons of taking students out of class due to research? If you were Siri's colleague, what advice would you give her before her next parent–teacher conference with Oscar? Justify the advice with support from experience and research."

1.2.2. The Implementation of the Simulation Resource

To have sufficient control over how the SPD was implemented, we decided to limit our study to the pedagogy class offered in the second year of a five-year teacher education program, at two campuses.

All the investigated simulation sessions consisted of three phases: a class brief, a group session where students worked with the resource, and a collective debrief. The three phases lasted from three to six hours in total. The teacher educators were given opportunities to adapt the design to their frames and semester plan. What was addressed in the briefs and how strictly the students used the suggested task sets therefore varied. One of the teacher educators merely introduced the simulated learning resources and the plans for the session, another addressed the assessment of pupils' learning and development and how to provide feedback to support pupils' learning, while a third included reading a specific research article as preparation for the simulation session.

In the second phase, the students worked with the simulation resource in groups. For example, they explored Oscar's video and the 16 documents that framed his conference, before discussing given questions, mostly selected from the presented task sets. Across all groups, the students were invited to approach the situations critically and with agency, exploring them, reflecting upon what they had observed, discussing dilemmas and problems, and suggesting how things could be improved. This second phase was organized similarly across all the classes, but the class who read an article as part of the brief was explicitly asked to draw on this when approaching the simulated situations.

In the last phase, the debrief, the students shared their main takeaways, suggestions, and justifications with the class. Some of them had been asked to make a PowerPoint presentation to present.

1.2.3. Data Sources and Data Collection

As mentioned, a survey, audio files, and field notes were analyzed to answer the research questions. The survey was initially developed for project purposes, to monitor students' experiences with the SPD and how it could be improved. It was piloted in 2021 and revised by our research group in 2023 (for example, overlapping statements were removed). In this study, the survey data (n = 39) were used because they gave insights into the students' perceptions of the simulation experience and its relevance for their future practice as schoolteachers. The questions in the survey covered their overall experiences with the SPD seminar and how they related to the videos and text documents, but also the students' use of the literature before and during the seminar. We selected the relevant statements where students were asked to express their level of agreement or disagreement on a Likert scale ranging from 1 to 5. Examples of statements include "I knew a lot about the topic the simulation resource addresses beforehand" and "I believe the experience gained from working with the simulation resource can be transferred to other, similar situations in practice". The survey was administered digitally and answered by the students after their experiences with the simulation resource.

To explore what characterized the process of professionalizing when student teachers were exposed to simulated school practices, we analyzed audio recordings and field notes. We recorded a total of 215 min from 11 group discussions and the class debriefs. The field notes were written while observing two classes working with the simulation. These data gave access to what the students identified as relevant in the material, as well as their approach to the material. They revealed how the students interpreted the situations, evaluated them, and identified dilemmas and problems, as well as their suggested solutions, including justifications.

1.2.4. Data Analysis

First, the audio files were transcribed. Second, guided by the research questions, all of the authors worked through the survey results and listened inductively to the audio files, taking separate notes. After discussing the notes and identifying preliminary findings, we agreed that a theoretical lens would be beneficial to investigate the observed professionalizing processes. The subsequent analytical phase was, therefore, theory-driven.

We found that Markauskaite and Goodyear's (2017) theory about epistemic fluency was useful. Epistemic fluency refers to the capacity to initiate and innovate knowledgeable action and build—but also contribute to—the development of actionable knowledge. Further, becoming professional involves not only developing knowledge for work but also knowledge for improving it. To improve work, teachers must be agentive and capable of critical thinking, they argue.

From Markauskaite and Goodyear's perspective, education is a key distance in the journey of becoming a professional, and they argue that professionalism involves four 'epistemic challenges': (1) linking or mixing theory with practice; (2) engaging in forming finely tuned professional skills; (3) raising critical questions and creating new and future-oriented knowledge; and (4) thinking outside the established "professional box". Through engaging with these, students can be prepared not only for the profession, but also for improving it. For example, students can use theories to solve challenges, or raise critical questions and think "outside the box" to stimulate evaluation, discussions, and improvement to practices. To identify if and how the students engaged in all these epistemic challenges, two of the authors mapped their presence by analyzing the audio files and field notes again. We identified snapshots showing the presence of the categories and presented them for the third author before discussing and validating the patterns with an extended research group.

2. Results

2.1. RQ1: To What Extent Do Student Teachers Perceive Simulated Practice Experiences as Relevant Preparation for Their Future Careers?

The first research question was addressed through survey data (n = 39). Students were asked to indicate the extent of their agreement or disagreement with a series of statements using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The survey data indicated that students' self-reported knowledge about the topic of parent–teacher conferences was limited. In response to the statement "I knew a lot about the topic the simulation resource addresses beforehand", only 5% of students selected "strongly agree", and 36% chose "somewhat agree". The majority (59%) responded with "neither agree nor disagree", "somewhat disagree", or "strongly disagree". This finding is important because it shows that the students in this study perceive themselves as lacking knowledge about the topic addressed by the simulation resource.

Working with the simulation resource may be one way of gaining relevant experience and knowledge, and the statement that most directly addressed the perceived relevance of the simulation resource was "I believe the experience gained from working with the simulation resource can be transferred to other, similar situations in practice"; 40% of the students responded with "strongly agree", while 50% chose "somewhat agree". This provides compelling evidence of the perceived relevance of the simulation experience for a future career as a teacher.

As described, the simulation resource consists of various videos and text documents. The perceived relevance of these specific components of the resource was also investigated in the survey.

When responding to the statement "The videos were relevant to me as a future teacher", 72% of students selected "strongly agree", while the remaining 28% chose "somewhat agree". This perceived relevance of the videos appears to be strongly linked to the videos' perceived authenticity in simulating real-life events. For example, when responding to the statement "the video clips showed situations that can occur in school", 67% of students selected "strongly agree" and 33% of students selected "somewhat agree".

In the survey, the students were also asked to consider statements that could help to illuminate more precisely what it was in the work with the simulation resource that potentially contributed to perceived relevance as preparation for a future career.

Most of the students report that the way the situations are recreated and made accessible enables them to identify challenges in school practices (46% somewhat agreed; 43% strongly agreed) and that all of the students expect the simulation experience to prepare them for handling similar challenges later (46% somewhat agreed; 51% strongly agreed).

Most of the students report that they gain new perspectives on parent–teacher conferences (13% strongly agreed; 59% somewhat agreed), and almost all students report that they gain experience in noticing important information and incidents (45% strongly agreed; 48% somewhat agreed), but also reflecting upon the incidents (44% strongly agreed; 49% somewhat agreed).

All students report that the simulated practice allows them to reflect upon situations they can encounter in their school practice (36% strongly agreed; and 56% somewhat agreed). Further, almost all students think that the simulated practice allows them to reflect critically upon the topic with peers (44% somewhat agreed; 44% strongly agreed), while fewer, but still many, report that working with the simulated practice has opened up opportunities to critically reflect with their teacher (20% strongly agreed; 44% somewhat agreed). These latter findings indicate that the SPD involves collaborative learning, where students relate to professional dilemmas and discuss these critically with peers and university teachers.

In the survey, the students were also asked to consider statements that specifically illuminate to what extent and in what way working with the simulation resource can help connect theory and practice. Here, the findings are not as unequivocal.

Over half of the students somewhat agreed (33%) or strongly agreed (26%) that simulated practice stimulates them to link theory and practice—more specifically, to use theoretical knowledge to analyze practical situations (20% strongly agreed and 45% somewhat agreed).

Lastly, and even though many students report that simulated practice stimulates them to link theory and practice, we also found that few students prepare theoretically for the simulated practice. When asked in the survey whether they prepared by reading about the topic, only 3% strongly agreed and 18% somewhat agreed. In comparison, 24% neither agreed nor disagreed, 21% somewhat disagreed, and 34% strongly disagreed. However, despite limited reading preparation and limited previous knowledge on the topic, working with the simulated practice seems to inspire some of the students to read more after the SPD session. When asked whether they are inspired to read more research of relevance after working with simulated practice, 16% strongly agreed and 27% somewhat agreed. Still, 41% neither agreed nor disagreed, 11% somewhat disagreed, and 5% strongly disagreed. Nevertheless, most of the students did report that working with the simulation resource made them curious to learn more about the topic (50% somewhat agreed and 26% strongly agreed).

In summary, the survey data show that student teachers perceive the simulated practice experiences as relevant preparation for their future careers. The vast majority find the simulated practice relevant and authentic, providing them with experience in parent–teacher-conference-related topics, about which many have limited prior knowledge. Further, the findings indicate that working with the SPD invites students to link theory and practice, but only to some extent. An explanation might be that the students, to a limited degree, prepare for the stimulated practice by reading the literature. There might, however, be other reasons. The audio recordings of the students' group sessions, which we present in the next section, will shed more light on this.

2.2. RQ2: What Characterizes the Process of Professionalizing When Student Teachers Are Exposed to Simulated School Practices?

When searching for key characteristics of the professionalizing process, a striking observation is how focused and on-task the student teachers are throughout the seminar. In one group, two of the students yawned a few times for unknown reasons. In the same group, one irrelevant Google search was also made, but the student was very soon back working with the task. Other than this, we observed nothing to indicate that the students struggled with staying focused. Rather, across all the eleven groups, we observed students working systematically and efficiently through each task. Below, we will provide snapshots from seven different groups exploring what the students are doing while being on task, using Markauskaite and Goodyear's (2017) epistemic categories.

2.2.1. Raising Critical Questions and Creating New and Future-Oriented Knowledge

A clear pattern in the material is that most students are highly engaged in what we recognize as indicators of raising critical questions and creating new and future-oriented knowledge (Markauskaite & Goodyear, 2017). We will soon show how through snapshots from three of the groups. For readability and transparency, we have chosen groups who all worked with Leander's parent–teacher conference and will start with contextualizing these snapshots, summating what happens in Leander's conference.

As mentioned before, Leander's mother is concerned that her son is unsafe, lacking friends in the class, and that he is gaming with older pupils, even during the night. The bedtime issue is particularly a problem when Leander stays with his father. Instead of following up on the mother's concern, the teacher, Linn, replies that Leander seems safe. To support her interpretation, she refers to Leander's self-evaluation form where he has marked two out of three stars when asked about his well-being in the class, in collaboration, during breaks, and on his way to and from school. The teacher asks Leander to tell her more about Dungeons and Dragons. The conference ends, and Leander and his mother leave the classroom, but the mother soon returns and says the following to Linn:

Mother: What just happened, I don't think it was okay. I am seriously concerned about Leander. He has no friends in the class. His friends are much older, and they spend a lot of time gaming. And when he is at his father's house, he is allowed to stay up as long as he wants. When he comes to me, I always need to be the one who must create structure and get him to bed, and it results in conflicts and quarrels. And then you choose not to follow me up when I say this? You could have. . . I need a grownup who can give me some support! I am thinking you also have children.

Linn: Yes.

Mother: Think how it would be if it were your children. Would you have thought it was ok then?

Linn: What I do with my children is another case, but I understand your concern. But it's also important for me to support Leander and be interested in what occupies him. When to go to bed, when to game, when to come home, that is something you must solve at home, and then we focus on the teaching at the school.

This simulated situation visualizes a dilemma about the limits of a professional teacher's responsibility. Below, we will give a snapshot of how three groups critically approach this conference. The first two snapshots were selected because these are from groups engaging with the SPD in very typical ways. The last snapshot was selected to show how specific questions from the task sets can spark critical thinking, even in a less critical questioning group.

Snapshots #1 and #2: Critical questions and various ideas about how the tensions could have been prevented or followed up.

In this first snapshot, the students start out agreeing, without question, that Linn is right when she thinks Leander is safe in the class. They interpret the mother's behavior and concerns as indicators of not being aware and properly interested in her son's situation and gaming interests. Nevertheless, the tensions between Leander's mother and Linn trigger them to discuss alternative approaches Linn could have taken to prevent the situation and deal with it going forward. A suggestion is to have separate meetings with Leander and his mother before a joint meeting. When considering this, they realize that Linn would risk increasing the number of meetings to organize and follow up.

Their interpretation of the situation changes when they find and read one of Linn's emails. It is from two colleagues who write that they are worried about Leander and whether he has friends. This makes them reassess the situation and approach Leander and his mom more openly. They start to search for reasons why Linn has doubted the mother's concern despite feedback from other teachers. After speculating for a while, they conclude that they will not find out and start searching for ways Leander could be better followed up in school. One idea is using games to increase his interest in the subjects, noting that this has inspired him to write Norwegian texts (they have seen an example of this among the text documents). Also, they suggest that the parent–teacher conference could have been better prepared. Information on the conference and the forms Leander should fill out before the conference should have been emailed to both parents, one says. Further, another proposes that in future conferences, the teacher should start with positive feedback, focusing on subject-related issues first and addressing social problems towards the end. One of them recommends starting by asking "How are you?" and avoiding negatively charged words and yes/no questions, such as "Do you find math difficult?" A better alternative is asking "What do you think about math?"

When sharing such ideas about how the teacher could have acted differently to prevent tensions or solve dilemmas, the students tend to refer to their own experiences with similar conferences, either as pupils or students having school practice. This is a typical tendency across the material.

As we will see in snapshot #2, what questions and ideas the students discuss varies, and what conclusions they draw when engaging with the simulated situations also differ. Below, we will look closer at one of the other groups grappling with what Linn could have done differently to acknowledge Leander's mother's concern. Student 1 comes up with an idea:

> Student 1: I think I would have a phone call with the mother afterward—it was positive that she talked about the father after Leander left. Maybe the mother could get help from the school nurse or someone else?
>
> Student 2: I also think the mother would have felt better if she had received a bit more acknowledgment—"Yes, I heard what you said."
>
> Student 3: I agree. She shifted the focus from the mother to Leander. But he is the one who should be the focus.
>
> Student 2: Do you think the father should be involved?
>
> Student 3: I don't know what the relationship between the father and Leander is like, but it seems like the mother has no control over Leander and no interest, but it would be interesting to see how the father would handle it.
>
> Student 2: If the father comes, I feel like the teacher becomes a marriage counselor—the focus might shift to their relationship instead of Leander.

Both snapshots illustrate how the students raise critical questions (Markauskaite & Goodyear, 2017) and generate a series of different ideas for alternative actions the teacher could have taken. It is typical across the groups that they do this on their own initiative and early in the group session. As shown, in some cases, they are triggered by observations in the videos, while in other cases, they are triggered by finding new information in a document forcing them to reconsider initial interpretations and perspectives. This is evident in snapshot #1, where it is emails from Linn's colleagues that make the students reconsider Linn's interpretation and search for alternative actions; Linn could take care to support Leander better at school. We see a shift from an initial agreement through a discussion of alternatives, which ends in a reevaluation.

Before we come back to the analysis, we will visit the group including the two yawning and one Googling student. These were less typical than the rest, because they largely maintained that Linn, the teacher, did everything right.

Snapshot #3: Tasks with power to spark critical reflection.

At the start, this group spent time considering the situation, particularly focusing on the mothers' behavior. One of them says the following:

> Student 1: It seemed like the mother was more frustrated with the home situation, really, but she blamed the stepfather a bit for not having strict rules and for Leander not doing what he was supposed to. It was more like a therapy session, really.
>
> Student 2: The mother asked if he [Leander] was good at math, and it was like, "Yeah, but he doesn't dare to answer because he doesn't have friends," and things like that. So, the mother completely misunderstood. . . There was very little focus on. . .
>
> Student 1: . . .development.
>
> Student 2: Yes, and the subject-specific things.
>
> Student 3: There was maybe more focus on the problem than on developing.

In what follows, they seem to agree that Linn did everything right. One of them argues:

Student 1: I don't think the teacher could have done much else, really.

Student 2: No (. . .)

Student 1: So, when the mother talks about all the worries (. . .) But those aren't her [the teachers'] challenges. What the mother is talking about isn't the teacher's problem. It's not the teacher's job to deal with it.

However, the conversation changed when they were given the following task:

If you were Linn's colleague, what advice would you give her before the next development meeting with Leander? Find support for your advice by drawing on the national intention description for parent–teacher conferences, experience, and research. One of the group members responded to the task by saying the following:

Student 1: I don't feel like she could have done much differently.

Student 2: But if you had another meeting, and they you would have had this parent–teacher conference six months ago, it would have been the same mess again. So, how can you prepare for that?

Among the alternative actions the students come up with in the talk that follows is speaking with the student alone to check whether he is feeling ok in class and at school. They suggest that this will lower the risk of misinterpreting the situation. One suggests that it might be beneficial to involve the father and have both parents present. This leads to a discussion about emotional issues that they think should be discussed in a separate meeting, without Leander. One of them cites the Education Act and notes that parents are primarily responsible for children's development. He uses this to justify his previous assumption that it is not the teacher's job to manage bedtime routines, for example. Another suggests that Linn should consult another subject teacher to check Leander's well-being and include this teacher in the next meeting to confirm Leander's status.

When presenting their main points from their discussions to the class, they note that the conference was somewhat disorganized, with the mother focusing on the negatives and the teacher trying to highlight the positives. Further, they emphasize the challenge of balancing private life and the teacher's role. When Leander's mother asked the teacher for adult support, the students evaluate this as a "power play" and an indicator that the mother is not fully engaged with what is happening at school. Then, they address that neither the mother nor the teacher investigates Leander's actual problem, or whether there is one. They conclude that before the next conference, they would have a proper conversation with the mother so that she and the teacher could reach a mutual understanding of Leander's situation, allowing them to focus on the intended purpose of the parent–teacher conference when Leander was present.

Snapshot #3 demonstrates that some tasks have the power to spark critical reflection. First, this group did not find reasons to question, examine, or evaluate different perspectives or possible alternatives. But then, because they were asked to give Linn suggestions for improvement, they were pushed to approach the situation again, this time more critically and analytically. If not, Linn, Leander, and Leander's mother would have been stuck with "the same mess". Consequently, it matters what tasks the students are given as these can mediate critical thinking. The task and collaboration lead to critical reflection and a search for alternatives, developing new and future-oriented knowledge (Markauskaite & Goodyear, 2017).

Looking across snapshots #1, #2, and #3 and relating this to the overall data material.

The above snapshots illustrate how the students, in their groups, create new knowledge that is future-oriented (Markauskaite & Goodyear, 2017), in the sense that they are addressing what could be done. In all of them, students generate ideas for how the dilemmas and tensions emerging in Leander's parent–teacher conference could be prevented or solved through alternative actions. On the list is having separate meetings with Leander and the mother; calling the mother up after the conference and putting her in contact with a nurse; including Leander's father in the meeting; directly checking with Leander to see if he is feeling ok; structuring the conference differently to maintain focus on Leander's situation and development; using alternative questioning techniques; and redesigning tasks to build on Leander's gaming interest. Similar action-oriented idea generation is also evident when investigating the overall dataset.

It is interesting to note that only the group visited in snapshot #3 explicitly suggests checking with Leander to confirm whether Linn's assumption about his well-being is correct. The group presented in snapshot #1, rather, focuses on the logistical risks of having to organize and follow up separate meetings with Leander and his mother before a joint meeting. The students from snapshot #2 search for ways to support Leander's mother, showing that they care and take her concerns seriously. At the same time, they are, in line with the group visited in snapshot #3, aware that engaging in a conflict between Leander's parents might go beyond their scope and responsibility. They may even end up acting as marriage consultants.

This tendency for the students to take different perspectives is typical across the overall data material. Some students also ask questions in the group sessions that the peers cannot answer. An example is "Could we have brought with us the principal to a parent–teacher conference?" No one in the group knows. In the debrief, selected students present some takeaways from their group discussion. However, they merely report them before it is the next group's turn. Consequently, the debrief does not involve sharing alternative perspectives and actions or discussions of unanswered questions.

2.2.2. Linking Theory and Practice

As shown above, a key characteristic of the students' professionalizing process is identifying alternative actions the teacher could have taken. They are frequently asked to use research or other frameworks to justify their suggestions. Nevertheless, they very often skip this, stating they have too little time to relate. However, there are exceptions, and from a professional development point of view, it is interesting to see what characterizes these.

Snapshot #4: Research and frameworks used to focus and/or justify their arguments and suggested actions.

As shown when describing how the SPD was implemented, it differs in how the teacher educators chose to brief the class. Snapshot #5 is from the only class where the teacher educator had picked out one text, using it as a lens for the students' observation. The text was Hellesnes' (2019) article exploring the bodily, relational, and existential dimensions of conversations in primary school, from a teacher's perspective. When observing this class, we made the following note:

> Another 'effect' of how the learning process was structured throughout the day was that Hellesnes' article regularly appeared in the students' presentations. Challenges and opportunities related to the physical space and the bodily aspects were highlighted by several groups. The groups were also 'assigned' to investigate during the practice period how parent–teacher conferences are conducted at the practice school.

Snapshot #4 gives an insight into the consequences of framing the simulation experience by including a deep dive into an article as part of the briefing. While none of the groups from the other classes focus on the physical space and bodily aspects of the conferences, this teacher chooses to draw their attention in that direction. This demonstrates how the literature can be used to help students see things that they might ignore without a theoretical lens. In addition, this snapshot shows a teacher educator treating the SPD as a learning activity integrated into a professional journey, including theoretical preparation but also an exploration of real parent–teacher conferences at the students' practice schools after the SPD seminar.

Even if the theoretical framing is vaguer in the other observed classes and the SPD is treated more like a one-day event, what the students discuss and read before is relevant and potentially applicable in the observed SPD. One group, for example, used research read before the session to argue for and against taking Oscar out of the class to read. With snapshot #3, we also observed a student using the Education Act to justify the teachers' choice to not engage with Leander's mothers' bedtime issues.

Linking theory with practice can, as Markauskaite and Goodyear (2017) point out, trigger preparation for a profession, but it can also trigger the improvement of professional practices if students, for example, use theories to identify an experienced or observed challenge and come up with alternative ways to approach it. The overall tendency in the material is that the students mainly apply experience-based knowledge when engaging in critical thinking and idea generation. As the students claim themselves, lack of time is probably a key reason for failing to search or apply theoretical frameworks. Nevertheless, when the students are theoretically briefed or prepared or even take time to search and relate to a relevant framework, it mediates focus and helps the students justify their perspectives and suggested actions, taking an agentic role in the SPD.

2.2.3. Thinking Outside the Established Professional Box

On the journey to becoming a professional, thinking outside the established "professional box" is listed as a beneficial activity in combination with engaging with critical thinking and linking theories and practice (Markauskaite & Goodyear, 2017). According to Markauskaite and Goodyear (2017), thinking outside the box often develops when engaging with different professional fields and different ways of knowing (p. 48). In our SPD, the students relate to open-ended situations and challenges, but do not collaborate across professional fields. Still, we searched for cases where they thought creatively, for example, by questioning established professional norms or taking perspectives other than the insiders' (teacher's or pupil's). Even if we found limited evidence for them thinking beyond their professional box, it happened a few times, as we will show in snapshots #5 and #6.

Snapshots #5 and #6: Questioning traditional school practices and seeing the school situation from a parent's position.

In the group in snapshot #5, a student questions whether it is a good or bad idea to ask pupils to fill out evaluation schemes before a parent–teacher conference. This sparks a discussion about the quality of the evaluation scheme, which is quite typical of what schools in the region use. The group starts out questioning whether the scheme gives relevant information and whether it would be better to use a five-point scale instead of a three-point one. Second, it is critical that the scheme is not anonymous, pointing out that this might limit how honestly the pupils will answer it. Finally, the group addresses that the teacher risks receiving superficial feedback from the pupils when asking many questions. To better reveal what the pupils struggle with, they rather suggest either creating a different scheme or finding other ways for pupils to prepare for the conference.

In another group, in snapshot #6, we recognize elements of thinking outside of the established professional box when a group works with Oscar's simulated parent–teacher conference. As we mentioned when presenting the SPDs, Oscar has just been diagnosed with reading and writing disabilities. His teacher is new and inexperienced, and in the simulated conference, Oscar's mother asks a series of questions and meets the teacher with clear demands and expectations that the teacher struggles to respond to. While most of the students working with this case merely take the teacher's and pupil's perspective and treat the mother as the major problem, one group approaches her differently. The following excerpt is taken from the fieldnotes we wrote when observing how this group analyzed the simulated situation:

> "On the one hand, the students perceived that the mother represented a problem for the teacher because she took the lead and partly dominated both her own child and the teacher in the dialogue, speaking with an accusatory and skeptical undertone. On the other hand, she expressed an engagement for her child's best. This made the student group discuss what the teacher could have done differently to collaborate better with the mother and make her engagement a positive force in the parent–teacher conference. This dialogical shift in perspective has both creative and analytical components. Interesting!"

In this group, their change in perspective triggers the dialogical shift. They realize that the mother plays a dual role: she can be recognized as overstepping and controlling the conversation, but her approach can also be seen as an indicator of her commitment to her child's well-being. Is she just doing her job as a mother? Realizing this makes them discuss whether the teacher could have harnessed this commitment more positively. By analyzing the situation, first from a teacher's perspective but then from the perspective of a mother, their dialog transforms from agreeing that the mother is the main problem to treating her as a potential resource.

In snapshot #5, the students question the use of an established school scheme, and in snapshot #6, they take on the mother's perspective, instead of seeing the situation merely from the perspective of the teacher and the school. We see these examples as attempts to think outside the box, and not just another example of critical thinking, because what they do requires questioning traditional ways of seeing. In snapshot #5, the students question a traditional school practice and suggest breaking with a professional tradition. In snapshot #6, the students discover and understand that the mother can be interpreted differently if they swap perspectives.

2.2.4. Engaging in Forming Finely Tuned Professional Skills

When designing the SPD, we wanted to engage student teachers in forming and finely tuning professional skills, such as investigating professional situations involving problems, identifying dilemmas, and discussing them. We also wanted them to create ideas and alternative actions by drawing on their own experience-based and theoretical knowledge. We were even curious about whether the SPD triggered them to think differently and challenge traditional ways of thinking that are typical within the "professional box".

We find that the open-ended simulation we have innovated and implemented encourages the students to explore and discuss a range of alternative perspectives and actions, related to roles, responsibilities, communication, power balance, psychological measures, schemes, and didactic techniques.

Despite limited evidence of student teachers thinking beyond established professional norms, they investigate the simulated situations, interpret what happens, discuss what they find, change their minds as they gain access to new information, and suggest many alternative actions the different teachers could have taken. In most cases, they argue for a teacher role, taking the lead in the parent–teacher conferences and asserting that the parent–teacher conference should be a safe space for addressing the pupil's development. In summary, the qualitative data suggest that the students interact and practice these professional skills, taking a future- and development-oriented approach to the simulated situations.

3. Discussion

3.1. Opportunities to Professionalize the Teacher Role

In this empirical study, we innovated simulations of parent–teacher conferences and implemented SPDs in a teacher education program to explore the opportunities to professionalize the teacher role through such designs. When designing the materials—the videos, text documents, and tasks—our intention was to expose students to complex, realistic challenges and enhance their agentic approach to these. We applied Markauskaite and Goodyear's (2017) descriptions of four epistemic challenges to investigate this, as their framework builds on an assumption that becoming a professional is a matter of developing knowledge for work, but also knowledge for the improvement of work. While developing knowledge for work involves adhering to established norms, improving work involves being agentive and capable of critical thinking, but also of challenging traditional ways of doing things within a profession. As highlighted in the introduction, such skills are highly valued in the workforce and are listed among key competencies by policymakers (Van Damm & Doris, 2022); therefore, we aimed to facilitate their development to prepare student teachers for their future profession.

The analysis of the survey clearly revealed that, in response to the first research question—"To what extent do student teachers perceive the simulated practice experiences as relevant preparation for their future careers?"—students perceived the simulated practice experiences as valuable preparation for their future careers. This indicates that we have succeeded in creating an SPD that facilitates better continuity between what the students experience on campus and in schools (Jenset et al., 2018). However, the connection between theory and practice was only partially achieved, possibly due to students' limited preparation for the simulation sessions.

Regarding the second research question—"What characterizes the process of professionalizing when student teachers are exposed to simulated school practices?"—we found that the students were highly engaged in critically reflecting on and generating ideas for how to improve simulated situations. Further, even if less typical, we also found instances of students linking theories with practice and "thinking outside the box".

Making intentional action-oriented choices when searching for how to make a significant difference implies agency (Engeness, 2021; Toom et al., 2015). When the student teachers approached the simulated situations, they were not just evaluating, but were also highly action-oriented and collaborative when searching for alternatives. As mentioned, thoughts cannot think themselves but emerge through interaction between humans and mediating artifacts (Vygotsky, 1978, p. 50). The investigated professional process was fueled by social collaborating, but also by interacting with the text documents, videos, and tasks. These resources came across as artifacts mediating future- and action-oriented professional development. Consequently, this study demonstrates that SPDs are valuable supplements to real school practices, as they make authentic and complex school situations accessible in campus-based learning and trigger professional development of relevance for the students' future role as schoolteachers.

3.2. Findings Related to Lessons Learned from Previous Studies

Our study both partly confirms and adds nuance to findings from previous research on simulation in higher education. First, from the survey, we found that students were highly engaged with the SPD. The audio files also demonstrate that the SPD fostered active, agentic learners, exploring the simulated situations. They collaborated on systematically and efficiently solving a series of different tasks. Others have also found that SBL promotes active learning (Chernikova et al., 2020), and collaboration and peer learning are highlighted as benefits (Levin & Flavian, 2020).

Previous research has demonstrated that SBL provides an arena for trial and error in a safe setting (McGarr, 2020; Levin & Muchnik-Rozanov, 2022; Flavian & Levin, 2023; Manburg et al., 2017; Militello et al., 2021). For example, in the project "Active professional development in a virtual world" (Faldet et al., 2021; Parish et al., 2024), student teachers took on the teacher role in a parent–teacher conference with a pupil and parent represented by two avatars. In our SPD, the students did not enact such a teacher role. It follows that they did not finely tune their professional skills (Markauskaite & Goodyear, 2017) through trying and failing as teachers in a simulated parent–teacher conference. Rather, they enacted as critical thinkers, to some degree as bridge builders of theories and practice, and as questioners of traditional ways of doing things in schools. In doing so, they practiced skills related to investigating realistic situations, interpreting and discussing observations, exploring information that challenged their perspectives, and identifying alternative actions different teachers could have taken in professional dilemmas.

Several studies have pointed out that SBL contributes to the development of student teachers' professional identity, confidence, and ability to act and be prepared for managing challenges and complex situations (Chernikova et al., 2020; Dittrich et al., 2022; Flavian & Levin, 2023; Yablon et al., 2021). Although we did not study professional identity issues, our findings indicate that after engaging with the SPD, students reported feeling better prepared for parent–teacher conferences. Furthermore, group discussions revealed that they actively related to the situations they anticipate encountering in schools. We hope such experiences will empower them for a teacher profession that continuously requests agency and efforts to adapt and develop. However, such long-term influence needs to be investigated in follow-up studies.

Where McGarr (2020) and Theelen et al. (2019) find that SBL bridges theory and practice, we find that this is not necessarily the case. The survey data revealed that more than half of the students found that the SPD helped bridge the gap between theory and practice; however, the audio files indicated that students only to a limited extent explicitly applied research to analyze the simulated situations and propose alternative actions. In several groups, the students mentioned that they lacked time to relate to the literature or research. However, in the class where the students were theoretically briefed by their teacher educator, such bridging was more typical. Consequently, student teachers seem to benefit from some sort of theoretical scaffolding. It is also worth noting that even if students, only to a limited extent, explicitly mention research, their research-based knowledge might implicitly impact, for example, their focus of attention in the discussions.

3.3. Reasons for Reshaping the Simulated Practice Design

As introduced, the SPDs in this study typically lasted three to six hours, including a brief, a group session, and a plenary debrief. The teacher educators were given opportunities to adapt the design to their frames and semester plan. In many ways, our study shows a successful way to design technology-enhanced learning to engage student teachers in agentic professional development. However, this study also identifies points that can be improved. Such insights call for reshaping designs in goal-oriented efforts to promote the best conditions for learners (Laurillard, 2012; Li et al., 2022).

First, we have found that even if the SPD represents an opportunity to apply both practical and theoretical knowledge in simulated practical situations, the students only explicitly apply theory in the group sessions and debriefs to a limited degree. However, when they do, they receive help to justify their suggested actions, and students who were theoretically briefed engaged more in linking theories and practice during the group discussions. This indicates that framing the SPD experience more effectively with theory is beneficial.

Second, the students report that they have too little time during the group sessions to relate to research or frameworks, but they also lack time to find answers to some of the questions they themselves raise in the group sessions. With more time, they would have better conditions for engaging more thoroughly with dilemmas, bridging the gap between theory and practice, etc. However, more time might not be enough for all. In a redesigned version, it might be worth paying attention to whether those with limited prior knowledge need more examples and prompting questions compared to learners with more prior knowledge (Chernikova et al., 2020).

Third, our study indicates that if we want students to think outside the box, they need more help. Modeling how unconventional thinking is performed is one potential initiative. Markauskaite and Goodyear (2017) suggest collaborating with other professionals. Outsiders tend to be better at questioning traditions that are easily taken for granted by insiders. In our case, bringing in outsiders could potentially help the students to push their discussions from focusing on "what to do"- to "why"-specific actions, which are either perceived as challenging or recommended. While there might be institutional barriers to bringing in outsiders, distributing whose perspectives to take when exploring the simulated situations could easily be initiated. As we saw in snapshot #6, when the students looked at the situation from the mother's perspective, they themselves managed to rethink and start searching for ways to approach the mother as a resource rather than a problem.

The value of debrief sessions has been highlighted in several other simulation studies (Mikeska et al., 2024; Dittrich et al., 2022; Yablon et al., 2021). Despite all the classes having debriefs, the students tended to only report on their discussions during these sessions. For example, they did not discuss the reasons why the different groups ended up with different perspectives, focusing on and suggesting different actions. Consequently, valuable learning opportunities were potentially lost. It is therefore essential to increase the duration of the debriefing sessions and not just request reports but also actively relate to the differences between the groups, linking theories and practice, and collectively practice thinking outside the professional box. More time for reflection and discussion among students can foster deeper critical engagement, leading to more innovative insights.

4. Conclusions

In this article, we shed light on opportunities to professionalize the teacher role through what we have called SPDs. We also discussed how our findings align with or nuance what others have found. Finally, we suggested how the SPD can be redesigned. However, in approaching the end of this article, we also need to underline that, in line with Markauskaite and Goodyear (2017), we perceive education as a key distance on the journey to becoming a professional. The above snapshots are from just one learning activity on this journey, and we know that some of the students, for example, were asked to participate in real parent–teacher conferences or talk with their school supervisors about such conferences after the studied intervention. There is, therefore, a high chance that some of the discussions in the groups will be brought up again in other learning situations.

In response to the call for this Special Issue, this paper "aspires to illuminate the complexities of enhancing agency in teaching and learning through digital technology, paving the way for innovative educational practices that respond to the opportunities and challenges of the digital era." This study makes a significant contribution in terms of innovation but also empirically and analytically. This study is innovative because it involves designing, implementing, and exploring how to foster student teachers' professional development, characterized by taking agentic roles when relating to complex, simulated situations. Empirically, we revealed that the students found it highly relevant to engage with the simulated practice design, and that they engaged with professional development when working with the simulated situations. By applying the notion of "epistemic fluency" (Markauskaite & Goodyear, 2017) as an analytical lens, we also add to the limited knowledge on how professionalizing learning processes, characterized by agentic learners engaged in critical thinking, can be studied empirically.

Limitations

Certain limitations of this study must be acknowledged. First, the number of survey respondents was relatively low (N = 39). While no inferential statistics were applied in this study, some claims were nevertheless made based on the percentage distribution of students' responses.

Second, the simulated practice experiences differ from the students' regular teaching activities on campus. Consequently, it is possible that some students, driven by their enthusiasm for engaging in something novel, may have overestimated the positive aspects of simulated practice. That said, the primary findings from the survey responses align closely with insights derived from audio recordings and field notes. This correspondence strengthens the robustness of the claims made in this study.

Third, while this study gives detailed and rich insights into a moment in the students' journey toward becoming professionals, it did not investigate the long-term benefits of SPDs on student's future professional practice. We therefore suggest that future studies follow up on the sustained influence of SPD as a training method. Designing a longitudinal study with an expanded sample, including interviews and engagement level monitoring during simulations, would yield more robust knowledge and potentially identify further areas for improvement.

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Article

The #BookTok Connection: Examining Cultural and Linguistic Identity Expression in Online Reading Communities

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Abstract: #BookTok, the TikTok sub-community for readers, has reshaped publishing and digital reading trends where marginalized readers find space to promote diverse books and stories beyond mainstream norms. This paper explores how three international #BookTokers with diverse cultural and linguistic backgrounds have found community, identity, and activism within this space, highlighting #BookTok's role in fostering inclusive and affirming literary communities amidst rising censorship challenges. This case study used thematic analysis to analyze participant interviews through open and axial coding to explore #BookTok engagement, framed through affinity spaces, transformative potential, and culturally digitalized pedagogies. #BookTok fosters belonging by connecting readers through niche interests, with the algorithm curating content aligned with identities. Participants reported shifts in reading behaviors and identities, with multilingual users expanding language repertoires to access and engage with diverse, identity-affirming texts. Content creation deepened connections, enabling advocacy for equity and justice. #BookTok is experienced as an affirming community where diverse texts and content creation can foster critical connections and promote justice-oriented actions beyond personal enjoyment of reading.

Keywords: TikTok; BookTok; diverse readers; reading motivation; culturally digitalized pedagogies; affinity spaces; digital literacies; reading communities

1. Introduction

#BookTok, the sub-community of readers and book lovers, has had a remarkable impact on the book publishing industry (Harris, 2021), the marketing of authors (Currenti, 2023), and the dominance of digital reading communities to promote reading behaviors (Asplund et al., 2024; S. Jerasa & Boffone, 2021; S. E. Jerasa, 2023; S. Jerasa et al., 2024; Merga, 2021). With 320 billion views (as of November 2024), this thriving community of content creators, viewers, and readers has built a space that has shifted how readers discuss, promote, or think about books. As a result of this powerhouse space, #BookTok is also responsible for some of the most popular book series, titles, and authors, such as Colleen Hoover or Sarah J. Maas.

The content within #BookTok spans from readers sharing their favorite books, suggesting new genres or tropes, or recreating favorite book scenes. Although popular or trending books and authors have held a steadfast regime within #BookTok, significant discourse exists for diverse readers who stray from the mainstream genres, tropes, or stories. In other words, the community of #BookTok is a space that promotes readers to gain visibility and connect with their peers who share similar interests, values, and identities (S. Jerasa & Boffone, 2021; Maddox & Gill, 2023; Wiederhold, 2022). As such, niche sub-communities within #BookTok have emerged, including #BlackBookTok, #QueerBookTok, #AsianBookTok, and #LatinxBookTok that reflect similar types or sub-categories of content (Dera, 2024a, 2024b; Maddox & Gill, 2023). While #BookTok can serve as a digital space to promote book awareness and reading behaviors, it can also contribute to algorithmically driven "rabbit holes" or "silos", limiting what users can view and access within the platform (Maddox & Gill, 2023; Krutrök, 2021). Despite this challenge, TikTok users can engage with content around books, genres, and authors not historically recognized or promoted within mainstream publishing. Therefore, these marginalized voices are privileged and given an impactful digital platform for discourse within #BookTok. Marginalized identities *can* find community within digital spaces in a way that promotes, supports, and affirms their specific interests, backgrounds, and experiences. Scholarship in other digital spaces has highlighted representation within a community is pivotal to developing reading identity, specifically for marginalized identities (cultural, linguistic, and sexual orientations) (Vasquez, 2005; Wargo, 2017).

The current landscape of book censorship and the politicization of worldviews has further emphasized the need for not only books or texts to reflect and represent diverse cultural and linguistic backgrounds accurately but also for environments or communities to exist to enhance, support, and encourage identity formation of all readers (Every Effort Matters, 2022). The importance of diverse representation within books can be affirmed as metaphorical windows, mirrors, and sliding glass doors and benefit marginalized and dominant identities (Bishop, 1990). Historically, educational spaces like K-12 schools have largely promoted White, middle-class, and heteronormative ideologies through curricula and text selections. Thus, third spaces (K. D. Gutierrez, 2008) or out-of-school spaces can serve as a refuge to form communities that adequately reflect such marginalized identities (Hill, 2023; Liang et al., 2024; Skerrett & Bomer, 2011). Situated spaces that privilege marginalized reading identities and voices are needed beyond schools to support those often left out of mainstream media and systems. In light of recent political pushback where book bans and censored literacies in the United States and globally have aimed to silence diverse perspectives, there has become a growing need for a space like #BookTok to serve as a safe space for readers with diverse cultural or linguistic backgrounds.

With such significant attention on this growing digital space, this study aims to capture the experiences of culturally and linguistically diverse #BookTok users and how their participation in this space contributes to their reading experience and identities. This examination also contributes to a growing body of scholarship on the importance and significance of digital spaces that promote critical and justice-oriented perspectives. By applying critical framings, this study presents how #BookTok is a digital space *and* a conduit for fostering critical reading communities through dialogic exchanges to support reading and identity formation. This paper highlights the cases of three global #BookTokers with diverse cultural and linguistic backgrounds and how their experiences emphasize ways this space has uniquely supported their reading identities and participation. This study will answer the following research questions: (1) What aspects of the #BookTok community support the diverse perspectives of individuals? (2) How have #BookTok users' reading behaviors or interests shifted due to participation in the space? (3) How do individuals participate in #BookTok to reflect their cultural and linguistic identities?

2. Theoretical Framework

This study is grounded in Transformative Potential and Culturally Digitalized Pedagogies (CDP), frameworks that align with their focus on exploring how #BookTok can serve as a space for justice-oriented and emancipatory practices among reading and culturally and linguistically diverse TikTok users. These theories aid in examining how marginalized users engage with TikTok to challenge inequities, build community, and foster civic activism, which includes the active participation to promote social, political, or environmental change within society. By applying these theoretical perspectives, this study considers the ways in which the platform might amplify diverse voices and facilitate meaningful digital participation for marginalized identities.

2.1. Transformative Potential

Transformative potential exists as a theoretical framework that acknowledges the systems of inequity to equip individuals with critical consciousness toward understanding their own identities and ultimately transform spaces for more equity through anti-oppressive interactions (Jemal, 2017). Transformative potential aligns with Freire's (2000) theory of critical consciousness to promote shifts and changes within a perceived oppressive system of normative experiences. Jemal (2017) posit that transformative potential extends the notion of critical consciousness from Freire (2000) and is "defined as levels of consciousness and action that produce the potential for change at one or more socio-ecosystemic levels" (p. 603).

Simply acknowledging or reflecting on inequitable systems is not enough to instigate transformation within a space. According to Jemal (2017), transformative potential is mainly situated within the individual and self-actualization before moving into disrupting larger systems. Jemal (2017) suggests that critical reflection leverages critical action in that "people do not blindly act to change oppressive social conditions without some consciousness that their social conditions are unjust" (p. 609; Watts et al., 2011). Actions toward transformative potential suggest that critical consciousness (Freire, 2000) is not necessarily a tangible end product, policy, or legal victory to disrupt systems of inequity. Rather, critical consciousness offers an individual and "psychological process of empowerment that stems from altering one's perception of self in society" (Jemal, 2017, p. 616; L. M. Gutierrez & Ortega, 1991) and ultimately affirms individual identities towards autonomy and equity.

Within spaces that privilege a mainstream or majority (White heteronormative) perspective, it is not so much discrimination or dismissal of cultures, backgrounds, or identities but rather the absence or lack of representation that silences the experiences or the existence of individuals. Particularly within published texts or trade books offered in schools, curricula, or mainstream media, the transformative potential exists by transforming discriminatory or oppressive spaces "as equitable, just, and liberating" (Anand & Hsu, 2020, p. 125) by pushing forward these often-silenced voices and experiences.

2.2. Culturally Digitalized Pedagogies

Extending the seminal critical work of culturally relevant pedagogies (Ladson-Billings, 1995) and culturally responsive pedagogies (Paris, 2012; Paris & Alim, 2017), culturally digitalized pedagogies (CDP) (McDaniel, 2024) centers the digital practices of culturally diverse youth and how these practices affirm, acknowledge, and support civic activism (Garcia et al., 2020) through engaging in actions that aim to influence public policy, raise awareness about critical issues, or advocate for justice and equity. Central to this work is the understanding that marginalized youth, particularly Black, Indigenous, and People of Color (BIPOC), utilize digital spaces to participate in online communities to foster a sense of belonging and engage in justice-oriented and critical conversations. The content for these conversations varies across platforms, topics, and formats, but what is central is how digital cultural wealth and capital are prominent in mobilizing and validating identities and diverse experiences shared by others with similar cultural or linguistic backgrounds.

As McDaniel (2024) notes, CDP prioritizes digital media as a central gathering and community builder for social-oriented activism in the digital work that BIPOC youth produce. McDaniel (2024) argues that youth are not only participating in digital spaces or social media to engage in entertainment but are prioritizing forms of communication to build community by "educat[ing] others through self-expression; engage in necessary conversations; seek racial justice and take on systemic racism, encouraging others to do the same; celebrate cultural and linguistic diversity; and create counternarratives to include accurate representations of BIPOC" communities (p. 200). As such, this work shifts the intention and purpose of digital content produced within spaces like TikTok towards a more unified and intentional construction. Content within TikTok varies across reading and special interest communities. However, the ways that BIPOC youth, according to McDaniel (2024), intentionally engage in digital discourse inclusive of "issues that impact themselves and their communities" (p. 201). This work aligns strongly with aspects within social practice theory where mediated actions within spaces help define an individual's identity (Cole & Engeström, 1997; Lave & Wenger, 1991; Vianna & Stetsenko, 2011). Similarly, Stetsenko (2017) developed the Transformative Action Stance, which aligns with CDP by emphasizing how participation in a digitally mediated space goes beyond mere contribution to actively shaping an individual's learning and self-understanding. Within CDP, McDaniel (2024) highlights the need for a broader engagement with the forms of digital literacy practices that BIPOC youth produce and consume. CDP moves critical examinations of digital youth productions towards reclaiming space and literacies that reflect their sociocultural backgrounds and experiences (Lankshear & Knobel, 2011; New London Group, 1996; Street, 1984). Although CDP supports pedagogy within educational spaces, this theoretical framework is appropriate for this study because it is grounded in the authentic digital spaces where diverse youth and #BookTokers engage, reflecting their situated experiences and community development.

3. Literature Review

In providing an overview of recent scholarship on TikTok and #BookTok, the following sections highlight the intersections of critical affinity spaces, restorying practices, communities of practice, and digital reading communities. This scholarship builds on how individuals from marginalized identities engage in transformative digital practices that amplify voices and foster collaborative meaning-making. By situating #BookTok within this scholarship, this review underscores its potential as a site for culturally digitalized pedagogy and social change.

3.1. Reading Identities Within Communities of Practice and Affinity Spaces

Affinity spaces are the formation of a community often found in digital or online spaces where group members share identities, interests, or goals (Gee, 2004). Gee (2017) operationalizes affinity spaces as being "primarily defined by an affinity for solving certain sorts of problems. As such they always involve the development of certain sorts of skills" (p. 28). Gee's (2004, 2017, 2018) work around affinity spaces have deeply informed other scholars within digital literacies to understand the influence, learning, and forming of identities through these online communities. Gee (2018) describes how classrooms and educators can learn from the exchanges in affinity spaces by mapping the various locations (physical and digital) and ways individuals interact with their interests by grounding examples from video gamers. Gee (2018) suggests extended offline activities (e.g., writing about their games, creating art, talking about gaming) are also a part of affinity spaces and developing identities. Leander and Boldt (2013) argue that literacies take shape beyond a textual product and how individuals form meaning as they engage in activities related to their interests. As Gee (2018) suggests, young people need access to these affinity spaces to explore their interests and deepen their understanding. Within affinity spaces, Gee (2018) offers that "people are fully engaged in helping each other to learn, act, and produce, regardless of their age, place of origin, formal credentials, or level of expertise" (p. 9). Individuals interact, engage, and extend their understanding of topics, interests, and passions through these spaces.

Beyond establishing a place of community, affinity spaces situate a hierarchical sense of membership where learning practices are exchanged within interest-based skills. Abrams and Lammers (2017) consider how affinity spaces provide a place of community due to the engagements, interactions, and exchanges between individuals. These spaces also provide belongingness for identity formation and align to components of communities of practice (Wenger, 1998). Lave and Wenger's (1991) communities of practice situate identity and belongingness to a community on the degree to which an individual engages as an expert in the field. Additionally, Lave and Wenger (1991) suggest that hierarchies exist between those with and without expertise within communities of practice. Curwood's (2013) study on Hunger Games fan-based online spaces (X/Twitter, Tumblr, YouTube, and Facebook) highlights that these affinity spaces, although digital and distant, allow for more collaboration and interaction with others than printed text (Lankshear & Knobel, 2011). Through an ethnography approach, Curwood (2013) analyzed the digital literacy practices and participation within a community, finding that youth gravitated towards affinity spaces to express their identities (Curwood & Cowell, 2011) and develop and maintain essential relationships (boyd, 2008). As such, affinity spaces are just as much community-forming as identity-forming. As Curwood (2013) suggests, literacy practices within affinity spaces move beyond traditional forms of comprehension and critical analysis, including a wide range of digital literacies, collaboration, and composing. Within affinity spaces like those described by Curwood (2013), individuals engage in the space and learn about community values, which develop and enhance their identity formation.

Identity is how we see ourselves and how others view us. While some identities are fixed, such as race, culture, or gender, we can choose other identities based on upbringing, jobs, training, or personal interests (Gee, 2004). According to Gee and Hayes (2011), our identities are based on our discourses, which are embedded with social language and "integrates ways of talking, listening, writing, reading, acting, interacting, believing, valuing, and feeling. . .in the service of enacting socially situated identities and activities" (p. 111). In defining reading identity, school-related discourses often come to mind where particular actions, interactions, and habits indicate that someone *is* or *is not* identified as a reader. Cultural models of the skills, actions, and reactions within a discourse ultimately define our identities. As such, Gee (2000) suggests that these identities and discourses of being a "reader", when they align with school-based discourses, impact the way a student acts, resonates, and understands language and literacy practices privileged by these academic spaces (p. 115). Therefore, the ways individuals view or think about a reading identity are often situated in the academic discourse of school-based reading and literacy practices. Reading identities frame how individuals see themselves and impact how they choose to carry out their identities whether in analog or digital spaces. Hall (2012) posits that students' identities play a significant role in how students choose to think and discuss a text, suggesting that cognitive ability is irrelevant in determining a reader's actions and reading strategies. This study notes that while reading identities can evolve through intentional environmental and social conditions, identities are often grounded in long-term developments and reinforcements from teachers, parents, and peers.

3.2. Restorying for Reading Communities

Extending Rosenblatt's (1994/2019) theory of transactional reading, Thomas and Stornaiuolo (2016) offer restorying as a bending of texts using social media. Namely, restorying is a process for readers to reimagine and "reshape narratives to reflect better a diversity of perspectives and experiences [as] an act of asserting the importance of one's existence in a world that tries to silence subaltern voices" (Thomas & Stornaiuolo, 2016, p. 314). For example, youth might recreate or respond to a text in a social media platform by using multimodalities to alter a characters' racial background, historical placement, or geographic location as a mechanism to bring *their* identities and experiences into the textual interpretation. Young people respond to the texts they are reading and move the ownership and agency of texts into their own hands to shift the time, place, identity, mode, perspective, and metanarrative. For readers from historically marginalized identities (i.e., BIPOC and LGBTQIA+ readers), texts often exclude their backgrounds, narratives, and experiences. Thomas and Stornaiuolo (2016) note that young people are engaging in restorying to bend narratives through digital networks and affinity spaces within social media (i.e., Tumblr, Twitter, Facebook, TikTok), taking up "new opportunities to connect, collaborate, and communicate, relationships between readers, authors, and texts" (p. 316). By reframing or bending the textual narratives, readers place their spin, which also situates notions of community.

Restorying reinforces many components of identity-forming actions (Bakhtin, 1981; Thomas & Stornaiuolo, 2016), which place the reader at the center of the textual interpretations, particularly within identities often left out, marginalized, or silenced. Additionally, the orientation of digital construction and reimagining exists as both learning and identity development (Engeness & Lund, 2020; Engeness, 2021). Thomas and Stornaiuolo (2016) state that "young people engaged in participatory culture produce individual and collaborative content as part of their everyday lives using a wide variety of multimodal tools to make meanings that are increasingly decentralized, crowdsourced, and situated in a multiplicity of contexts" (p. 318). This extends what Rowsell et al. (2019) describe as adolescents' preferred interactions to interpret digital texts, seeing it less as a literal translation but engaging in remixing or reimagining to interpret deeper meaning.

3.3. Hacker Literacies

Aligning within digital communities of practice are also "hacker literacies" (Santo, 2011), the sociotechnical engagements that are "empowered participatory practices, grounded in critical mindsets, which aim to resist, reconfigure, and/or reformulate the sociotechnical digital spaces and tools that mediate social, cultural, and political participation" (p. 2). In other words, the ways individuals engage in digital practices that shift or alter their original intent or purpose to build, bring together, and empower others. Santo (2011) describes the best example of hacker literacies as hashtags that have morphed specifically on platforms such as X/Twitter, Instagram, and TikTok. Commonly used to identify or mark a group, keyword, or phrase, hashtags (#) are social identifiers that construct varying forms of meaning (Zappavigna, 2015). An example of this "hack" was in 2007, when Messina (2007) suggested the migration of using hashtags in Twitter (now X) as not just an identifier but as an organizing tool around important issues (Carvin, 2009; Gannes, 2010; Santo, 2011); as Santo (2011) argues, hashtags were never intended to be a social organizer. However, hashtag participation has rewritten how the X/Twitter platform is used for critical participation. In essence, hacker literacies align with how individuals may reframe digital tools to mobilize others, collectively building a community of shared interests and values. Although much of Santo's (2011) work examines hacker literacies through social activism, the malleability of social media platforms and digital technologies as communicative and community formation tools warrants consideration for the content and material for marginalized identities.

3.4. Online Reading Communities

Online book communities are growing in popularity, where readers gather through online or socially mediated digital platforms to post, blog, recommend, or discuss books. Foasberg (2012) discussed how social media spaces, like X/Twitter, provide a socially interactive space for book clubs and reading communities as “many participants posted links to their blogs, but others also used it as an opportunity to encourage each other or make note of the books they had read or other aspects of their lives that affected their reading” (p. 50). Interactions that serve as a form of reader response extend beyond the individual reader and a text. Instead, they progress toward a deeper understanding of community development within these digital spaces through social interactions about their reading.

Online reading communities can offer individuals a more enhanced experience to discuss and deepen literary understandings beyond reading a text independently. Colwell et al. (2018) found that youth participating in online book clubs experienced richer reading experiences compared to independent reading. The online setting allowed for academic discussions with minimal adult interference and encouraged more meaningful connections between participants. The space afforded a sense of autonomy to choose texts and engage in discussions that reflected personal identities and experiences, which led to deeper, more nuanced interactions with both the texts and fellow community members.

3.5. TikTok: The Social Media Platform for Gen Z

TikTok is a short-form video social media app that has overtaken U.S. popular culture. Since 2018, users in the United States have created and interacted with three-second to three-minute-long videos, virtually engaged with followers, and developed digital communities based on interests, identities, and passions. The literacies within this digital platform exemplify how literacy is fostered by a community, constructed through video-based content, and consumed by users. The platform, structured by an algorithm, permits and limits how users, contributors, and the TikTok community view, use, and compose content. Boffone (2021) suggests that the way young people (particularly in Generation Z or those who were born between 1990 and 2010) choose to use and engage with social media spaces is indicative of the way “young people. . .view social media as a critical place to construct identities and form distinct youth subcultures” (p. 10). TikTok is more than just a dance app. It situates itself as a source of social or pop-culture currency for emerging communities and affinity spaces to exist based on interests, passions, and identities.

TikTok’s platform as a social media space permits interactions among and between users (Nichols & LeBlanc, 2020), and participation in the TikTok community relies on the algorithm’s personalization. Like many other social media platforms, TikTok emphasizes content curated for its users (Ruehlicke, 2020). However, TikTok’s platform is distinct in delivering content directly *to* users based on previous activity and learned user behavior (Ruehlicke, 2020). TikTok is unlike other social digital platforms like X/Twitter, Snapchat, or Facebook, where users are the primary agents for seeking, finding, and selecting their community, content, and followers. TikTok’s technical platform structure aligns with the techno-skeptical constructs described by Nichols and LeBlanc (2020), who argue that platforms inherently and intentionally bring individuals and interests together, highlighting that “all of these activities are intimately bound up with digital relations that are not always immediately visible to us” (p. 107). In this way, TikTok’s algorithm mutually connects and segregates users into concrete categories or communities without user manipulation. Ruehlicke (2020) suggests that TikTok’s inclusivity is presented as having spaces for everyone, not that everyone is equally welcome in all spaces. To engage in a particular community or content, users must actively “teach” the platform through their actions, engagements, and viewing patterns. The platform upholds power as it decidedly pushes content to the screen's forefront by default, asking users to make choices within the provided content. The platform's tools allow users to make targeted choices within the content provided, allowing a user an assumed perception of their literacy engagement, agency, and access.

This digital community is not without critique. TikTok's algorithm often pushes content that promotes White heteronormative ideologies, which perpetuate offline systems of inequity (Boffone, 2022; S. Jerasa & Burriss, 2024; Tanksley, 2024). Other social media spaces have also been criticized for their hidden or subversive algorithms that privilege normative aesthetics, ideologies, or perceptions. In 2020, X/Twitter received criticism for its image-cropping algorithm, which would crop out or focus on the most significant part of an image. As Hearn (2020) describes, this technology's bias chooses to promote white components of images while cropping out Black and Brown faces. Within TikTok, this preference for whiteness is sometimes not as apparent as it is masked within the interconnectedness and hidden algorithmic components. As such, "rabbit holes" or "silos" can function as promoting bias through the algorithms preference for particular trends or user behavior patterns (Maddox & Gill, 2023). Boffone (2022) describes the TikTok bias when he says, "TikTok is built around TikTokkers mimicking the platform's most-followed accounts. That is, the repetition and virality of ...videos, trends, dances, and aesthetics [that] replicate whiteness" (p. 23). This is not to say that historically marginalized identities, such as Black or Brown individuals, are not using this space. Instead, they *are* recreating these digital spaces to celebrate and elevate their identities and experiences through hashtags and subcommunities. Acknowledging TikTok's hidden or subversive side, historically marginalized identities have used or found community within TikTok. For example, Martinez (2022) studied how Black teenage girls use TikTok to construct spaces of Black joy as a form of resistance against White supremacy and racist systems of oppression. While TikTok's algorithm often amplifies certain voices, the platform can be used by Black, Brown, and LGBTQIA+ youth to actively engage and carve out spaces that serve their own needs and foster critical communities.

3.6. BookTok: The Sub-Community of Readers

#BookTok is a thriving TikTok sub-community that brings readers and book enthusiasts together to share favorite titles, recommend genres or tropes and creatively engage with their literary passions. #BookTok provides a space for meaningful interaction among readers while leveraging TikTok's multimodal tools, including audio, video filters, and music, to create engaging and emotionally resonant content (Merga, 2021; Wiederhold, 2022). #BookTok has garnered significant attention from readers, publishers, and the broader book industry. Its influence is evident in the rise in marketing strategies, such as Barnes & Noble's #BookTok-themed displays and publishers collaborating with content creators for book promotions (Balling & Martens, 2024; Harris, 2021). This growing synergy between social and economic forces demonstrates #BookTok's ability to shape literary trends and consumer behaviors, empowering teens and adults through a shared passion for books (Reddan et al., 2024).

The platform offers a space for users to exercise autonomy and agency, finding books (Dezuanni et al., 2022) through videos that often reflect personal interests rather than adhering to external rules or evaluations (Boffone & Jerasa, 2021). This dynamic shifts how individuals discuss and experience YA literature, making YA texts "memeable, fun, engaging, and socio-culturally relevant" (S. Jerasa & Boffone, 2021, p. 221). Recent scholarship has found that #BookTokers engage in the space not only to discuss books but as Asplund et al. (2024) posit, to "confirm, develop, and challenge their own reading practices" (p. 648) through social approaches, such as shared annotations or reading in a physical space with others. Additionally, Dezuanni and Schoonens (2024) argue that #BookTok can be positioned as a learning space as a form of peer pedagogies (Dezuanni, 2020) where content creators serve as teachers about "reading identities, critical thinking in book selection, goal-setting in reading, pleasure reading, and importantly, the value of media entertainment in encouraging reading" (p. 9). Dera et al., (2023) explored students' "reading personas (e.g., bookworm, book doubter, or book avoider) to determine their potential #BookTok usage, finding that students with a positive reading attitude and who frequently read, viewed #BookTok with strong appeal; however, those with negative reading attitudes were less likely to use the space.

Overall, recent scholarship has confirmed the potential and power to inform and shape individuals' reading behaviors and identities through digital participation. Since #BookTok frequently elevates marginalized voices and stories often excluded from traditional school curricula, fostering discussions, book clubs, and content around these texts. This inclusivity transforms #BookTok into a literacy space where youth can encounter diverse cultural, queer, and linguistic representation, creating a safe and affirming environment for self-expression and acceptance (S. Jerasa & Boffone, 2021). While Asplund et al. (2024) and Dera et al. (2023) both emphasize the potential impact of #BookTok on readers with varying attitudes and interests, neither study explicitly included the perspectives of individuals from diverse cultural or linguistic backgrounds. Therefore, it is important to understand such perspectives in order to determine the significance, application, and nuanced aspects of #BookTok for diverse readers. #Booktok scholarship has noted that the majority of content focuses on mainstream, popular texts or authors that reflect White, heteronormative perspectives (De Melo, 2024). De Melo (2024) found through a comparative analysis of the race, gender, and sexual orientation identities of #BookTok content creators, authors, and texts finding that although diversity exists, the space is, however, dominated by mostly White, female, and heteronormative texts, authors, and content creators. Despite this finding, diverse content still exists that serves as both representational and affirming community space for non-dominant viewpoints. Extending work by Martens et al. (2022) and Kulkarni (2024), #BookTok can be an affirming space for readers of diverse cultures and linguistic practices that are often not recognized in other online or analog spaces. As such, this study addresses a gap in #BookTok scholarship by examining how international creators with diverse cultural and linguistic backgrounds and how the space fosters community, affirms identities, and advocates for equity.

4. Materials and Methodology

This work is part of a larger mixed-methods study on the reading motivations of users associated with #BookTok. This study utilized an online survey instrument to investigate reading motivation and reading perceptions of #BookTokers and recruit study participants for interviews. The scale instrument included questions where participants rated their reading identities today and as youth in elementary school, which provided data on respondents' identity shifts as readers. Given the emerging scholarship on TikTok research, particularly its algorithmic and human–machine interfaces, limited methodologies have been developed. The researcher first engaged in a walkthrough method (Light et al., 2018) for systematic interaction with the platform to saturate the algorithm in order to effectively recruit participants for surveys and interviews. Over four weeks, hashtags like #*BookTok* and #*bookish* were used to curate content that aligned with the interests of the #BookTok community as a training tool for the platform's algorithm. This process provided the research-specific TikTok with semi-randomized, algorithm-driven content, ensuring a deeper understanding of the community's digital patterns and creating opportunities to recruit participants effectively. Between June and August of 2022, the researcher contacted 1646 TikTok users through direct messaging and email to complete the survey instrument. A total of 525 recorded survey responses were collected; however, 450 were eligible for analysis to determine scale values for reading perceptions and #BookTok-related reading motivation. All survey respondents were invited to opt-in as interviewees; however, only those participants who indicated a reading identity shift from youth to current day were considered eligible. A total of 42 participants met the interview eligibility criteria, and only 20 completed the consent to participate. It was determined that six to eight interviewees would be appropriate for the scope of this study. Six interviewees were selected using demographic data to ensure diverse perspectives across genders, race/ethnicities, languages, and sexual orientations. For the scope of this paper three of those interviewed participants were selected as case studies. The section below details this study's participants and their credentials. The Institutional Review Board approved this study at the author's institution (STUDY00003042).

4.1. Participants

For this paper, selected participants were international #BookTokers who shared experiences of having varied linguistic experiences in schools where their home or primary spoken language was not the dominant language used in their schooling or early elementary education. For this study's analysis, three participants from the six that were interviewed in the larger study were selected as cases as these participants identified as non-White individuals and resided in a country outside of the United States. Participants shared ways their experiences with #BookTok promoted a diverse cultural experience and affirmation for the texts they read. The following section provides an overview of each case in this study.

4.1.1. Armand

Armand is a 22-year-old Middle Eastern male currently living in Germany, where he is a college student. He was an Iranian refugee, and his family left home and moved to Albania when he was in high school. Armand identifies as multilingual, speaking and reading in Farsi, German, and English. Armand is an avid fantasy reader and describes his purpose for #BookTok, which is to mostly connect with others who like to read his favorite types of books. During the interview, his TikTok account had 13.4K followers and 1 million likes with 715 videos. Armand described that access to TikTok was ultimately limited until he began college in Germany since the Iranian government restricted access to the app.

4.1.2. Gibson

Gibson is a 26-year-old Queer Black male currently living in the Netherlands as a college student studying international creative business. He grew up in Curaçao and speaks and reads in multiple languages, including Dutch, English, and Papiamento, which is the native language of Curaçao. Gibson's TikTok account includes 430 videos with 653K likes and 18.4K followers during the interview. Gibson started chronicling his reading using an Instagram account, which quickly migrated to TikTok. Gibson's #BookTok content focuses mostly on book recommendations for texts that include people of color and queer stories.

4.1.3. Robin

Robin is a 26-year-old Filipino Asian female self-proclaimed "dog-ear and spine-breaking reader" who enjoys reading nonfiction books. As a multilingual, Robin speaks and reads Tagalog (an indigenous language of the Philippines) and English but prefers to read texts in English because more books are available. Robin views her participation in #BookTok as part of a larger movement for advocacy and activism against the current political situation in her country and the banning of books (or red-tagging) that are critical of the country's current government. At the time of her interview, Robin's TikTok account had 370 videos with 305.4 likes and 6348 followers. Her #BookTok content focuses mostly on books she recommends that privilege female and Asian voices.

4.2. Data Collection

The researcher applied a case study (Merriam, 1998) approach and examined the bounded unit of global #BookTokers' participation in the digital platform who experienced a shift in reading behavior from their youth. Due to the focus of this study, only interview data collection and analysis are reported. Data sources included three participant interviews (see Table 1), and interviews were conducted via Zoom in August and September 2022, with video recordings capturing audio, facial expressions, pauses, and other non-verbal communication. Using Carspecken's (1996) interview protocol, data focused on understanding participants' intentions, reactions, and perceived implications of their contributions within TikTok. Discussions explored three key domains: (a) the rationale and intentions behind #BookTok engagement, (b) perceptions of elementary reading experiences and early reader engagement, and (c) reflections on participants' current reading lives. In order to capture how participants constructed #BookTok content and understand their engagement in the space, video elicitation (Banks & Zeitlyn, 2015) was applied to triangulate findings and provide visual support for the participants to view, recall, and discuss their experiences.

Table 1. Interview Participants Across Demographics, n = 3.

	Racial Identities				Language Use		Gender		Age	Geographic Location
	Hispanic	**Black**	**Asian**	**Biracial**	**English**	**Multilingual**	**Female**	**Male**		
Armand			X			X		X	22	Germany
Gibson		X				X		X	26	Netherlands
Robin			X			X	X		26	Philippines

4.3. Data Analysis

The author applied a thematic analytical approach (Merriam, 1998) where interview transcripts were examined and coded for themes aligned with critical affinity spaces (Abrams & Lammers, 2017; Curwood, 2013; Gee, 2018), transformative potential (Jemal, 2017), and CDP (McDaniel, 2024). The researcher first used the raw transcription data to open code (Glaser & Strauss, 1967) to determine how the interview transcript data emerged through an inductive analysis (Miles et al., 2020). Drawing from critical affinity space, CDP, and transformative potential, child or sub-codes were determined through a more inductive approach for understanding the more nuanced components using axial coding (Corbin & Strauss, 2015; Merriam & Tisdell, 2016) for themes and connections to the theoretical framework of culturally digitalized pedagogies particularly focusing on aspects of culturally focused digital productions, reflections of personal lives, notions of belongingness toward community formation, and engagement towards activism and allyship (Jemal, 2017; McDaniel, 2024) (see Table 2 for coding scheme). Coded data and child codes were validated by Dr. Dominique McDaniel to confirm findings and alignment to theoretical framing with emphasis on CDP. For analysis validation, the author confirmed participants' statements with their reading motivation survey responses as a form of member check.

Table 2. Data Analysis Coding Scheme.

Parent Code	Child Code	Examples
#BookTok Community	Shared Interests	"My friends or people around me [don't] have the same [book] tastes as me. So there were no person [sic] around me to like talk about. . .books."
	Distinctive Membership	"I started accumulating followers and having conversations with people all around the world about just queer books, and that's . . .how I made a lot of my friends today."
	Authentic/True Reflection	"You feel safer, you can be who you are without having to have everything staged."
	Space for Diverse Backgrounds	"Anything that is MLM (Male Loving Male) is already a plus for me. . .And now, getting to read these books, knowing that they exist is amazing.
Critical Perspectives	Access to Social Currency	"If you want to be in like the inner circle, you need to like read the books that everybody [reads]...otherwise you won't get the jokes, you won't get the videos."
	Understanding Others	"I was completely ignorant to the existence of other ethnicities in general. The [understanding] that me and this [other] person, we were not the same. . .didn't exist."
	Understanding Selves	"These are like the kind of books that I wished I would have known existed when I was growing up and what would have helped me so much with my identity and self-assurance."
	Taking action	"Right after the election was called, everyone was panicking about books being banned."
Shifts in Reading	Reading Identity	"I found reading in high school, but when I was, uh, younger it was my sister who reads. . ..Eventually I became the reader."
	Diverse Representation	"Afterwards I was like, craving more because I didn't know queer literature was an actual genre."
	Language Access	"So I think I had read all the translated fiction that was about fantasy. You have this one shelf with translated texts."
Reader's Response	Dialogic Interactions	"I get comments like, 'Oh, do you have anything for like a new adult sapphic romance?' or something like that, and I just reply to those comments with videos and with either books that I have or books that I know
	Shared Reactions	"When I'm reading slowly it's because I like to like live react, live tweet or just like live text. My friends like, oh my God, you'll never guess what just happened. And then just, um, start a conversation from that.
	Reflecting Identities	"Say if a book has two love interests. . .let's say they are both white, I always try to imagine the other one as a person of color. Yeah, because I just like seeing people of color in these stories.
	Responsibility to Community	"This kind of forces me to like, do research and look for books, because I don't want to leave the [#BookTok] people hanging."

5. Findings

This overview of findings first examines how the #BookTok community is presented according to our participants' experiences and how the community reflected shared interests, authentic representation, and distinctive membership while serving as an inclusive space for diverse backgrounds. The second theme of findings centers on the critical perspectives that were discussed by #BookTokers and how the content provided access to social currency (Moje et al., 2008) and served as a mirror, window, or sliding glass door (Bishop, 1990) to deepen understandings of varied perspectives. The third theme pointed to the shifts #BookTokers experienced as readers due to their participation in the digital space compared to their reading experiences from their youth. Lastly, findings connected to how participants engaged in #BookTok as a form of reader response and how their content and engagements reflected their reading practice and identity with others.

5.1. #BookTok Community

#BookTok emerged as a distinctive community in participants' descriptions, with some noting how they discovered it or how the algorithm introduced them to the reading community. Armand described being intrigued by TikTok despite having limited access to it in his home country of Iran. Armand would use backdoor tactics such as watching book-related TikTok videos through YouTube shorts, which were not restricted. Once Armand's family relocated to Armenia as refugees and later moved to Germany, he could finally access and download TikTok, where he noticed how the platform's algorithm found book-related content that was very specific to his niche interests of epic fantasy. Armand noted that he quickly was able to lean on the algorithm to find other readers who shared the same interests as him, as he described, "The way the [TikTok] algorithm works is that you find your exact copy [sic]". Similarly, Robin first began using TikTok due to her curiosity about the "new" space. Robin noted that the platform surprised her because she immediately found other accounts that shared her interests, specifically discussing characters and quotes from books. She described that she stumbled upon #BookTok by chance and noticed that her content feed became more tailored to books when she said, "It really clicked in little by little. . .when I was fully in [#BookTok] that's when I realized I was really having fun". For Robin, she said that feeling seen by content that reflected her interests made the experience of using TikTok particularly unique and enjoyable.

The community feeling of #BookTok was mostly described as not just content but the creators, viewers, and fellow readers that really made the space distinctive. For Armand, he described that his analog or in-real-life (IRL) friends or family did not have the same reading interests. He explained that although he loved to read, he did not note anyone to share his ideas or new thinking with. He described this when he said, "the type of books that I read are not what necessarily my friends [read]... and people around me [don't] have the same taste as me. So like there was no person around me to like, talk about this. Like books, fantasy books". To Armand, #BookTok became his virtual reading community. Gibson also felt a sense of community with the users of #BookTok since he first started using TikTok during the COVID-19 shut down, when he felt isolated and alone without friends and family nearby. He quickly discovered a thriving community around books when he said, "I started accumulating followers and having conversations with people all around the world about just queer books, and that's sort of how I got into #BookTok and that's how I made a lot of my friends today". For Gibson and Armand, this interpersonal connection and feeling of social interaction allowed for the #BookTok community to mimic and mirror what they would normally do with friends or family within analog settings.

Participants described the feeling of the #BookTok space as being distinctive compared to other social media spaces, namely that TikTok felt like a more authentic space where they could share aspects of their identities without fear or critique. Armand described his participation with #BookTok noting a sense of security and familiarity as he engaged with content through leaving comments, responding to content creators or viewers, and liking videos. Armand described his approach to creating content in #BookTok as feeling comfortable to show his face to discuss his favorite fantasy books or characters without worrying about having a perfect bookshelf as his backdrop. Robin additionally noted on the distinctive feel of TikTok and described her first interaction with the platform saying, "[it was] the first time I [was] able to show myself in [a] video without makeup on. . .looking like I just woke up. I can't do that in Instagram. That's why TikTok is my preferred social platform". To Robin there was something special about this platform space that allowed her to feel safe and transparent about the books she loved and found most interesting. This was something she hadn't experienced in previous social media platforms before.

The #BookTok community was often described as the space or access point for reading suggestions or recommendations. Although participants described that popular or mainstream authors and texts were common within #BookTok content, there was an overwhelming sense that diverse authors, stories, or texts were privileged and welcomed within the digital reading community. Robin described how she only knew about certain authors based on popular media but that the #BookTok community helped her find books that reflected her own interests when she said, "the quality of the content . . .it's more catered to what I like. Before [#BookTok] all I know [sic] are the ones I see in TV, like Nicholas Sparks and Dan Brown. And now I can find more [books or authors] that's not really as famous, but will speak more to me". Robin made clear that her reading interests focused on finding and reading texts written by female Asian authors, and the #BookTok community helped her find those texts. Gibson also found that the #BookTok community supported varied interests and diverse books. Gibson described the content creators he followed as being reflective of his specific interests, saying,

> One thing I really like about the people I'm following is that it varies a lot. . . there are some people that I follow specifically that talk about like books and their love of Greek mythology, and others talk about diverse books and specifically talk about books like Black authors [and] Black protagonists. . . There's like a circle of people that I'm just excited to see what [they] post on a daily basis.

For Gibson, the #BookTok community afforded him a space for multiple and intersectional identities to co-exist. In this way, Gibson felt like his curated content helped him to find creators and books that reflected his varied reading interests and supported his identity as a Black, queer male.

5.2. Critical Perspectives

Findings noted that participants' #BookTok engagements supported their ability to take up critical perspectives. This included reading similar texts to be part of a robust and dynamic discourse across the #BookTok community. Commonly understood as social currency (Moje et al., 2008), one must have social knowledge or inside information (e.g., reading a popular or controversial book) to be included in the conversation but also to be able to make sense of it. Participants noted that reading particular texts meant they also understood the commentary or discussion about it. It simultaneously supported their community membership while also allowing them to take a particular stance on a discourse. Armand noted this when he described that being part of the #BookTok community also meant he had to read similar books and authors discussed within #BookTok videos. He described wanting to understand the inside jokes. He wanted to make content that his community members would understand when he said, "if you want to be like in the inner circle, you need to like read the books that everybody [reads]. . . otherwise you won't get the jokes, you won't get the videos". Armand noted that this active participation helped him to build an understanding for the varied perspectives, discussions, trends, and jokes that often were present in #BookTok.

Participants also described their #BookTok participation as a way that deepened their own sense of themselves and their identities. This occurred through the content they viewed or created and the books they selected to read from #BookTok. Robin described her reading behaviors as enjoying all types of books but described that when she read books or authors aligned with her cultural experiences as a Filipino female, her reading experience was significantly more impactful. Robin could feel a difference in how she read a text with Asian characters. She noted how she could internally understand their experiences, saying, "I think I am moving farther away from books with only white characters and more [books] with the diverse ones. Which is better. . .especially if it's Asians, like I relate to them more, like understand each other more". To Robin, this deeper level of understanding by reading diverse and representational texts allowed her to experience books in a different way. This allowed her to make deeper connections with characters and stories, affirming her identities. Gibson also noted that reading books and authors who reflected his identity as a Black, queer male changed how he saw himself as a reader when he said,

> Because these are like the kinds of books that I wish I had known existed when I was growing up. And it would have helped me so much with my identity and self-esteem because I was very insecure as a child. And now I'm getting to read these books, knowing that they exist is amazing. So whenever I find any recommendations [that include] male representing romance with Black people, it's like, "okay, give it to me".

To Gibson, reading and participating in a space like #BookTok provided access to texts that enhanced his reading and his understanding of his intersecting identities.

Bishop's (1990) metaphor for diverse texts highlights that books can serve as mirrors and windows to understand others' cultures and lived experiences. While two out of the three participants described their reading of diverse texts and participation in #BookTok as affirming their own identities, Armand described that his #BookTok engagement allowed him to see perspectives beyond his own culture. Armand grew up in Iran, where he often did not see cultures outside his Middle Eastern background. He described being unaware of other racial or ethnic backgrounds, saying, "So basically until 13 or 14 [years old] I was completely ignorant to the existence of other ethnicities in general. The [understanding] that me and this [other] person, we were not the same. . .didn't exist". However, Armand noted that by participating in Instagram, X/Twitter, and TikTok, he was exposed to cultures and perspectives different from his own experiences growing up in Iran, which ultimately broadened his worldview.

Understanding critical perspectives also included taking up civic action to address issues of inequity or injustice. Robin described how #BookTok supported her reading and how she mobilized her account to support other readers within her home country of the Philippines. Robin described the political situation in her country as "tense" and "problematic" since the 2022 presidential election of Ferdinand Marcos Jr., son of the country's former dictator. Robin explained how her country's democratic society has experienced significant threats due to fears around book bans and censorship of printed materials that oppose the current political ruler or referenced "subversive, anti-Marcos, anti-Duterte contents" (Santo, 2011). To this, Robin said:

> After the election, we had some very disappointing results, and afterwards I knew I wanted to use my [#BookTok] platform to be [an advocate] for our country. . .Right after the election was called, everyone was panicking about books being banned. [Censorship] is going to happen eventually we were all so sure, so we bought every [book] we could. . .There is already a ban happening on what can be published. I want to do my part in helping the younger generation have these . . .books written by our own.

Robin saw her #BookTok space as an opportunity to promote books written by Filipino authors in her native language, Tagalog, and to preserve her culture's history.

5.3. Shifts in Reading

Participants were selected for this study based on their identified reading shifts compared to their elementary schooling experience using a scale instrument at the time of recruitment in addition to their cultural and linguistic demographics. A direct cause or correlation was not named in participants' reflections, but some noted changes in their reading behaviors compared to their earlier experiences. Individual accounts described shifts in reader identity, particularly in how they now perceive themselves as readers compared to their elementary school years. For example, Robin described that she wasn't the "bright" one in her family and that her sister was considered the strong reader, saying, "when I was younger it was my sister who read and I always thought it's so sad that [reading] is not for me. Like I wish it was but it wasn't. Eventually I became the reader". Robin noted that she initially did not identify as a reader but later transitioned to see herself as someone who reads. Gibson also alluded to his reading ability as a barrier to his reading due to low self-esteem. He noted that he didn't start reading or see himself as a reader until 2019 when he made a New Year's Resolution to read more books. Gibson selected queer books that really interested him saying, "I found *Simon* Versus *the Homo Sapiens Agenda* (Albertalli, 2015)... and I devoured this book in like 2 ½ days... and mind you I haven't really read or finished a book before this. Afterwards I was like, craving more because I didn't know queer literature was an actual genre". For Gibson, having discovered a genre or book with diverse representation unlocked an urge and desire to read that shifted not only his behavior but how he identified as a reader. He noted that texts available to read in elementary school did not interest him due to a lack of representation. Simply put, Gibson did not see himself in any of the books he could read. Gibson commented on this when he said,

> The books that I saw didn't really represent me. I didn't see myself in any of the characters physically. Sometimes even personality wise, I didn't see myself... Now [Black characters] are in books, in movies, or TV shows. I think the very first time that I even felt... represented in any piece of media was watching Cyborg in *Teen Titans*. I was like, 'Oh my God! A Black superhero, finally!'

The fact that Gibson now has access to types of books and media that are inclusive and reflect his own identities has contributed and affirmed his current-day reading behaviors.

Another pattern that came up were the ways participants described the quantity and format of books that they read. Robin noted that she has significantly increased how many books she reads per month and even keeps track of her books using an online app in addition to her #BookTok content. Robin described this by saying, "Now I read around, uh, nine to ten books in a month or like nine to twelve. Before that I only read like two to three books in a month. Like sometimes none". Robin attributed her high volume reading success to #BookTok saying, "because of #BookTok, the books I find now are better suited for me. I am having a lot more fun with them because they are written for me". Armand also acknowledged that his volume of reading increased due to not just the genre or topic of books but the format, namely audiobooks. Armand described his reading behavior shifted when he started using audiobooks for reading saying,

> I love audiobooks. [Reading has been] really hard for me. It was something that I always noticed even by studying, especially for academic stuff. I can't sit in the same place and just read. I need to always be doing two or three things at the same time. I usually put on an audiobook and put it on 2× or 3× [speed] if it's possible in the app.

Armand noted that this reading format change allowed him to unconsciously focus on a text and story while also doing other activities like video gaming, driving, or artwork. Utilizing the audio features of an audiobook also allowed Armand to get through texts quickly, which would be harder to do if he only read the text alone.

Alternatively, Gibson noted that his reading behavior shifted towards a more slowed and intentional pace where he would read only for pleasure. Gibson noted that his reading purpose shifted how he read a book explaining if it was only for him, he wanted to savor the experience saying, “my reading habit is a little slower. . . it’s more for my own enjoyment and honestly I’m not tested or anything. Most of the time when I am reading slowly it’s because I like to live react, live tweet, or just like live text”. According to Gibson, this slowed approach to reading allowed him the opportunity to engage with others about the books he was reading, making the meaning more impactful to his own thinking.

The three participants noted that the availability of texts in their primary or home language was a barrier to their early reading behaviors. Armand described how his linguistic practices often limited his access to the reading material he loved. Armand’s first language is Farsi, and he described that in bookstores, he was often limited in what he could read since most books were published in English and his English language was still developing. Armand said, “Fantasy [the genre] especially is not a big thing in Iran, [so] the amount of translated [books] that I had access to was limited. . . So I think I had read all the translated fiction that was about fantasy. You have this one shelf with translated text”. As a result, Armand was motivated to learn English to gain wider access to the books he wanted to read and participate in online conversations. Robin also described a similar experience as she noted that few books are written in her native language of Tagalog, the basis of national language of Filipino, and so she often had to read books in English, saying, “I’m comfortable reading in English. I tried to read Tagalog book once a few months ago but I did not finish it. . . I feel like there’s not a lot of books written in Tagalog. . . The language is I think a barrier too to Filipino readers”. Not having wide access to books written in accessible languages prevented participants from being able to engage with texts they wanted to read fully.

In addition to linguistic limitations, Gibson highlighted that school settings privileged books that were not written in his home language. Growing up in Curaçao, Gibson’s first and home language was Papiamentu, a Creole dialect of Portuguese. His schools used Dutch for all instruction and learning materials, including books. Despite these challenges, Gibson shared that he identifies as multilingual and fluent in multiple languages, including Papiamentu, Dutch, English, and German. As a child, Gibson shared he felt a divide in his linguistic repertoires and avoided texts written in Dutch. He has since shifted and described his reading choices based on content rather than linguistic representation when he said,

> [My parents] would always get Dutch books and I didn’t really like them. . .[but] I’ve noticed that even if a book is in Dutch, [if] it’s interesting enough, I will read it. Like I have a few now that are in Dutch that I’ve read because I just like the premise. It takes me a little while longer, but I like them.

To Gibson, what started as a significant barrier to accessing texts shifted as he gained more autonomy in the books he could read based on his interests, even if the language were more challenging to consume. As Gibson described, the story and characters made the challenging language worth reading.

5.4. Reader’s Response

Participants described how their participation in #BookTok took up varied positions where they created content, viewed videos, and followed or commented on accounts. The three participants described #BookTok as their preferred space for discourse to talk with others about books. This was often due to not having in their everyday life available to share books, recommendations, or ideas about genres, authors, or characters. Armand described that although people in his family were readers, no one shared the same specific interests as him. #BookTok afforded Armand a place to have discourse with others despite not knowing them IRL saying, "So I'm [sharing books] with basically strangers in the internet, like [to] have a community online that have a same interest as me". According to Armand, these shared interests in epic fantasy books allowed him an opportunity to enjoy the genre and encouraged him to read more.

Gibson also described how discourse about books has really supported him as a reader, feeling that he had an audience to share his thoughts about authors, stories, and even subgenres of texts. Although Gibson's videos began with just funny anecdotes, he started to include more book-related content when viewers began responding and engaging with him. This feedback not only reinforced Gibson's decisions on what types of content to create but gave him a sense of how his content impacted others' reading. Gibson shared that a lot of his content were responses to comments and questions about books that addressed Black or queer experiences highlighting a sense of obligation to help others find titles or authors for queer literature when he said, "I get comments like, 'Oh, do you have anything for like a new adult sapphic romance?' . . .and I just reply to those comments with videos and with either books that I have or books that I know". In this way, Gibson saw his participation and reader response as a responsibility to support other readers in the same way he was supported when first joining #BookTok.

Although reading is often described as an individual practice, Gibson and Robin noted they engaged in buddy reading or book club discussions as a result of #BookTok. Robin explained that this form of reading behavior started as a way to encourage others (e.g., friends, family members, fiancé) to read more but also fostered her own reading saying, "now that I have found #BookTok I have also encouraged [my best friend] saying, 'maybe these are the kinds of books you would want' so now we have like a two-person book club". Similarly, Gibson described that he and his #BookTok friends would often read a book together saying,

> I buddy read with two of my friends and what happened was we just read at our speeds and. . . when they caught up to me we just had this exchange back and forth of what we think is going to happen. Like we exchanged theories of what's going to happen to the characters.

For Gibson, this form of shared reading and discussion about books became part of the way he read his books and thought about reading, which translated into his #BookTok content.

6. Discussion

The #BookTok community fosters a sense of belonging through shared interests, diverse perspectives, and broadened worldviews while influencing individuals' reading habits and content-creation practices. Across the three cases, findings highlight the impactful role of language in book access and the transformative changes participants experienced in their reading. These insights have practical implications, demonstrating how representation in texts and opportunities for discussion outside traditional educational contexts can deepen engagement with literature globally. The discussion is organized around the study's three guiding research questions and themes to explore how the #BookTok community supports diverse perspectives, how participants experienced shifts in their reading behaviors, and the ways participants used #BookTok to reflect their cultural and linguistic identities.

6.1. #BookTok Community: Affirming Identities for Sense of Belonging

Participants revealed #BookTok's importance as a secure and inclusive space where users could meaningfully connect with other readers who affirmed their cultural and linguistic identities. According to participants, #BookTok fostered a sense of belonging by connecting readers with similar niche interests, such as epic fantasy or queer literature. Such assemblages aligned with affinity spaces (Abrams & Lammers, 2017; Gee, 2018) namely in the formation of bounded groups based on shared identities and passions. Although notions about the #BookTok community are not new (Dera, 2024b) there appears to be a deep affective pull that encourages the participation of the space (Kulkarni, 2024), particularly those with positive reading attitudes (Dera et al., 2023). Robin noted how her enjoyment of TikTok shifted once her curated content included books she identified with and wanted to read. For Gibson, it became the other #BookTok community members that fostered his emotional connection. #BookTok's community and interactions within the digital space afforded participants a welcomed sentiment and allowed them to develop identities as readers and individuals (Gee, 2018; Vianna & Stetsenko, 2011). Within #BookTok, participants also noted the sense of membership within the space, namely, understanding jokes or inside commentary by reading commonly known or popular books. In this way, #BookTok includes a hierarchical membership of those who read and know the same types of books, authors, or tropes to understand the defining characteristics of such sub-communities or identities.

#BookTokers described the platform's algorithm as crucial in curating specific content that aligned with *their* individual preferences. This also enabled users to find and engage socially with other like-minded readers. As such, #BookTok became less about the digital space or the algorithmic curation and more about the individuals who made up the community. This centering of the community made participants feel safe to share their ideas, identities, and opinions (McDaniel, 2024). Despite critical views on the authenticity of TikTok's content and creators' intentions due to economic profits (Florida, 2022) or microcelebrity status (Abidin, 2021), participants felt seen and supported by their fellow #BookTokers. On the surface, this sense of belonging might only look like standard connections or textual discussions on favorite genres, tropes, or books. However, beyond these shallow interactions, participants saw the #BookTok space as intimate, allowing their true selves to exist. Participants noted that this experience with TikTok contrasted their experiences with other social media platforms or IRL spaces. Through affirming conversations, participants shared that #BookTok was *their* community to engage with the critical issues significant to their identities, communities, and lived experiences.

Participants described their #BookTok experiences as opportunities to be seen and heard where their identities were affirmed. This affirmation also served as an intentional carving out of space by utilizing the digital platform for their discourse around particular topics closely associated with marginalized identities (Jemal, 2017) beyond just their common interests in books (Asplund et al., 2024). It is well known the book publishing industry reflects a predominantly White, monolingual author population with books that overwhelmingly revolve around or promote White heteronormative ideologies (So & Wezerek, 2020). Additionally, there have been critiques on how social media algorithms like TikTok maintain a bias towards non-dominant viewpoints and individuals through algorithmic coding (Boffone, 2022; Tanksley, 2024). This is largely due to the algorithm creating echo chambers of content that reflects the larger discussions and behavior patterns. Critics have suggested such "silos" of information and viewpoints as problematic (Maddox & Gill, 2023), where content is continuously reinforced within a closed loop, limiting exposure to diverse perspectives and excluding outside voices from the conversation. However, the findings highlight that participants felt included within #BookTok because they could openly discuss representative texts or topics that reflected their linguistic and cultural practices, lived experiences, and identities. In many ways the algorithm performed its part to find "siloed" content that was inclusive of the types of content users wanted to see. Participants noted that the fact that they saw themselves in the texts that were discussed or, as Armand said, "your exact copy", provided a sense of community that took up a transformative potential stance (Jemal, 2017). Participants acknowledged the overwhelmingly absent or lack of representation in media, including books, TV, and social media. However, the participants noted that their participation in #BookTok affirmed these identities and viewpoints (Vianna & Stetsenko, 2011). As such, the #BookTok community proactively empowered their experiences or existence (L. M. Gutierrez & Ortega, 1991; Jemal, 2017) by digitally discussing and affirming their reading practices and interests.

6.2. Shifts in Reading Behaviors

Findings highlight the multiple ways participants experienced shifts in their reading compared to their previous experiences as youth. Measures for this study did not conclude correlation or causation patterns for the direct impact of #BookTok participation and changes in reading behaviors. However, some described specific ways their reading habits evolved since engaging with the #BookTok community. The most prominent thematic pattern was access to a wider and more varied selection of texts. While this access is likely influenced by multiple factors—such as age, economic flexibility, and autonomy—several individuals discussed how #BookTok contributed to discovering books that better reflected their cultural and linguistic identities. For example, Gibson and Robin noted that #BookTok helped them recognize the existence and legitimacy of books featuring protagonists aligned with their interests, such as Black queer male or Asian female leads. While #BookTok did not create or validate these genres, they credited the space for facilitating their discovery of such texts. This experience also extended to linguistic access, as all study participants identified as international and multilingual speakers who previously struggled to find books that matched both their interests and language preferences. Reflecting on their current reading experiences, individuals shared that they now have greater access to books that incorporate their preferred languages. Language appeared to be a more significant barrier during their younger years, when their linguistic repertoires were still developing. As adults in their twenties, they described themselves as stronger speakers and readers in their non-native languages, such as English. Consequently, these shifts seemed to stem more from increased proficiency and access to books they enjoy rather than from the format of the texts themselves.

In addition to the access to books, participants noted that their reading identities or viewing themselves as readers shifted significantly. Although it is unclear what role #BookTok played in this shift, participants said they revised their understanding of what it means to be a reader by interacting with others who shared similar reading habits and interests (Asplund et al., 2024). Through #BookTok, participants found other readers who could share their thoughts about texts and felt encouraged that their approaches "counted" as reading. In many ways the role of the platform's algorithm affirmed their choices by assisting to find content that validated the ways they wanted to read. This shift points to affinity spaces where participants were affirmed as readers to develop their reading identities through the digital community (Gee, 2018). Although it is likely that multiple factors also contributed to these shifts in participants' reading identities, findings suggest that #BookTok played a role in facilitating these changes and in how the participants view their reading today.

Participants shared a shift in what or how they read texts and their overall purpose for their reading. Namely, participants wanted to be part of the #BookTok discourse and have a reason to discuss a book with an IRL individual or analog community (Asplund et al., 2024). Armand noted that he sought out TikTok to be a part of the conversation about epic fantasy authors and books. Gibson and Robin said their reading purposes were to share their thoughts through book club discussions or buddy reading. Gibson shared that his slow approach to reading significantly changed because he wanted to read for his pleasure and share his authentic reactions with others through live reacting. In this way, participants acknowledged that their reading shifted due to wanting to share their reading experience with others. Whether it was an online or offline discussion, participants noted that they were reading to be able to express themselves, build a community (McDaniel, 2024), and contribute to the larger conversation taking place.

6.3. Representation Through #BookTok Participation

Literacy scholar Bishop (1990) coined the metaphor "Books as mirrors, windows, and sliding glass doors" to highlight the importance of diverse representation within books for young readers. Her metaphor still holds for adolescent and adult readers as findings highlight how diverse representation in texts supported participants' racial, linguistic, and cultural identities. Although some individuals initially joined TikTok out of curiosity or to explore the space, their continued engagement with #BookTok ultimately stemmed from finding affirmation of their own cultural and linguistic identities through both consuming and producing bookish content. In alignment with the concept of restorying, study participants engaged in identity-affirming actions through their book reviews, recommendations, and textual interpretations, all of which were informed by their identities, cultural or linguistic backgrounds, and lived experiences (Thomas & Stornaiuolo, 2016). This continued engagement allowed them to carve out a distinct space to validate their experiences and existence (Jemal, 2017) and to create counternarratives that celebrate their cultural or linguistic diversity through texts (McDaniel, 2024).

Although participants noted that #BookTok was an affirming community of like-minded readers, findings also highlight how participation served as civic activism or advocacy towards emancipatory justice. Gibson noted he felt a sincere obligation towards providing accurate and affirming content that promoted Black, queer authors or texts for his followers and fellow #BookTokers to enjoy. To Gibson, he was responsible for supporting his community and advocating for them through his content. Additionally, Robin highlighted how her #BookTok platform became a hub for book access in response to book bans taking place in her country. In this way, Robin intentionally challenged the political oppression and regulatory systems by hacking the original intent of her #BookTok platform and community (Santo, 2011). As such, Robin mobilized awareness to address the political and racist issues that deeply impacted her and her fellow Filipinos (McDaniel, 2024). Although the broader societal impact remains uncertain, participants engaged with #BookTok in nuanced ways to cultivate literacy practices that reclaimed this space, authentically reflecting their sociocultural, linguistic, and ideological identities and experiences (Lankshear & Knobel, 2011; New London Group, 1996; Street, 1984).

7. Implications

This study highlights the theoretical implications of #BookTok as a digital space where marginalized communities reshape traditionally oppressive platforms to serve emancipatory purposes. In contrast to TikTok's algorithm, which typically amplifies content reflecting dominant White, heteronormative ideologies (Boffone, 2022; Tanksley, 2024), these #BookTok users actively reimagined the space to prioritize diversity, inclusion, and liberation. This aligns with the concept of New Literacies, where digital and multimodal approaches to literacy challenge traditional practices (Lankshear & Knobel, 2011; New London Group, 1996; Street, 1984). By intentionally engaging with the platform in ways that amplify identity-affirming content, marginalized users not only reshaped the digital environment but also trained the algorithm to prioritize diverse voices and experiences. As a result, #BookTok functions as a "third space" (K. D. Gutierrez, 2008) where these often overlooked identities are celebrated, fostering community building and solidarity that extends beyond book discussions to empower participants (Santo, 2011; McDaniel, 2024).

These findings confirm previous scholarship on TikTok and underscores the practical significance of #BookTok as a dynamic digital space for agentive creative expression and community building. While digital activities on platforms like TikTok are often dismissed as trivial or unproductive, findings confirm such digital spaces are powerful sites of meaningful composition where users actively produce, share, and consume content that shapes identities and fosters meaningful connections. Participation in these digital spaces influences emotional and intellectual experiences, such as reading, and helps develop critical ideologies central to identity formation (Engeness, 2021; Vianna & Stetsenko, 2011). Despite the possibility that TikTok may not remain a permanent fixture in popular culture, it highlights how youth and digital users can harness social media platforms to create and navigate spaces that challenge dominant narratives and disrupt the status quo (Jemal, 2017). In this way, #BookTok offers a meaningful opportunity for digital creation and the cultivation of a critical, transformative community.

The engagement observed on #BookTok points to a broader shift for application within in-school or out-of-school reading practices. Reading is no longer only an individual activity but can be a collective, community-driven experience. By creating and sharing multimodal content, #BookTok facilitates a participatory reading culture where conversations about books extend beyond personal reflections to include collective identity promotion and civic activism aimed towards creating positive change or addressing societal challenges. When #BookTok content emphasizes the experiences of BIPOC, Queer, and marginalized readers, it fosters a supportive, critical reading community that transcends traditional reading practices present in educational settings. In this digital space, reading becomes a social endeavor (Asplund et al., 2024), where meaning is constructed from the text and the discourse and connections formed through shared experiences. This transformation emphasizes a more inclusive understanding of literacy, acknowledging the diverse identities and experiences reflected in the texts people read and the conversations they participate in. #BookTok can allow individuals to redefine themselves as readers, validating their unique identities through their chosen discussions and texts. The collective, affirming nature of these conversations underscores the importance of digital spaces in shaping modern reading practices and fostering critical identities in both online and offline contexts.

8. Limitations and Future Research

Participants in this study reflected multiple linguistic and racial backgrounds with global perspectives. While this diversity highlighted participants' unique experiences, it also resulted in the clustering of various viewpoints. As a limitation, the study was unable to thoroughly examine the nuanced experiences of specific marginalized groups, such as Black, LGBTQIA+, Latinx, or Asian communities. Future research could address this limitation by focusing on the particular linguistic and cultural dynamics within #BookTok sub-communities to understand better how these identities navigate and reshape the space. Additionally, this study was part of a more extensive study that focused on the relationship between #BookTok and reading motivation. As such, future research could include a scale development with culturally digitalized pedagogy (McDaniel, 2024) with affinity space theory (Abrams & Lammers, 2017; Gee, 2018) to capture the interplay between platform engagement and reading habits. The relatively small sample size of the study presents a limitation where generalizability cannot be attained. Future research can include larger samples through surveys to construct more transferable findings. Another notable limitation is the black-box nature of TikTok's AI-driven algorithm, which heavily influences participant selection and content curation. While this study employed methods to control for algorithmic bias, future research could explore how the algorithm shapes marginalized identities' ability to find and engage with their communities, offering opportunities to unpack its role in fostering or hindering inclusion within #BookTok.

9. Conclusions

#BookTok serves as a potential site for transformative potential within CDP and affinity spaces. This study examined the experiences of culturally and linguistically diverse #BookTokers, focusing on how this digital space influenced their community participation and reading behaviors. #BookTok can be understood as a space that shifts the concept of reading from an individual activity towards a more collective and community-driven practice. Participation in #BookTok can be a purposeful act of connecting with others, advocating for diverse representation in literature, and affirming marginalized identities. By leveraging culturally digitalized pedagogies (CDP), #BookTok empowers users to challenge the status quo and promote transformative advocacy for equitable representation in books and reading practices. These practices, shaped by the platform's algorithm, provide personalized content that can foster civic activism, social justice, and empowerment.

This research contributes to the broader understanding of how digital platforms can function as spaces for cultural sustainability, civic engagement, and transformative educational practices, offering insights for educators, researchers, and policymakers aiming to leverage technology for equitable literacy practices.

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education sciences

Article

The Analytical Gaze of Operators and Facilitators in Healthcare Simulations: Technologies, Agency and the Evolution of Instructional Expertise

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Abstract: This article analyses the coordination between professionals, students and technology in the communication and appropriation of know-how in healthcare simulations. To be successful, simulations require continuous interventions by professionals (in this case, operators and facilitators), who analyse, assess and reflect on the actions participants take as the simulation evolves. This study builds on interaction analysis of 30 video-documented (15 h) conversations between operators and facilitators in post-simulation discussions of outcomes. The specific focus of the analysis is the nature of work done by operators/facilitators as they analyse and evaluate simulations. The results show the multilayered nature of these analyses. The operators and facilitators show three prominent types of consideration. They (a) calibrate what they have observed, (b) monitor the progress of the scenario as an instructional event, and (c) comment on their own contributions as instructors/participants. All these considerations have evaluative elements, and the agentic nature of technologies, students and professionals is addressed. One general observation of interest is the ways in which simulations provide access to student learning, and how these activities become accessible for professional scrutiny and judgement.

Keywords: simulators in learning; operators and facilitators in simulations; simulation in healthcare instruction; interaction analysis; technologies and agency

1. Introduction

During the past 100 years, simulators have come to play an increasing role for learning and instruction in professional training. Beginning in fields such as aviation and healthcare, simulators have been used in diverse settings, including vocational training (Braunstein et al., 2022), business education (Beranič & Heričko, 2022) and training of mariners (Sellberg et al., 2022), for example. In recent years, simulations have made their way into the regular educational systems through the use of virtual labs, virtual microscopes and similar resources (Lantz-Andersson et al., 2019).

In the present study, we examine the work of operators and facilitators when orchestrating learning and instruction in the context of full-scale simulators in healthcare training. Such environments are often well resourced and have access to qualified technical and healthcare staff with extensive and varied experiences of simulations. Successful execution of simulations requires continuous interventions by professionals, who monitor and evaluate what actions participants take as the simulation evolves (Wiig & Säljö, 2024). Our empirical focus is on the roles that operators and facilitators play in promoting meaningful and challenging learning opportunities in critical exercises in healthcare. More specifically, the analytical focus is on the joint agentic elements of participants and technologies in the co-creation, monitoring and development of a dynamic space for learning healthcare practices.

In research on healthcare simulations, the role of operators and facilitators is considered essential to simulations (see, e.g., Dieckmann et al., 2008; Husebø et al., 2024; Nordenström et al., 2023; Sawyer et al., 2016). In the literature, the terminology used for defining the roles and responsibilities of those who run simulations varies (cf. The Healthcare Simulation Standards of Best Practice™ (HSSOBP™) Operations, Decker et al., 2021). Usually, there is a division of labour in simulations, which implies that the operator primarily is responsible for "running the computer" (Seropian, 2003, p. 1698), while the facilitator is responsible for the exercises and for the instructional relevance of the debriefing. But, in practice, the roles are often not as clearcut as this. A simulation is a dynamically evolving process, where technology, pedagogy and healthcare work are intertwined and difficult to separate. This means that operators often, in addition to their responsibilities for the technology, will contribute by playing different roles in the scenario (doctor, patient and relatives), and facilitators will intervene with technologies, by supplementing the decisions on how to use technology with healthcare relevant input.

While simulator research describes the simulation process as a method most often organized as Briefing—Exercise—Debriefing, our interest in how operators and facilitators contribute is often thought of as the "backstage" work of professional evaluation and analysis in the learning environment. However, in addition to the three stages conventionally focused on, there is a critical part (Phase 3 in Figure 1), during which teams of operators and facilitators analyse the simulation that has just taken place and prepare for the debrief with the students. The work they do here is both retrospective and prospective. During this stage, the operators and facilitators analyse and evaluate the simulation, and, among other things, they decide if student performance lives up to expected standards.

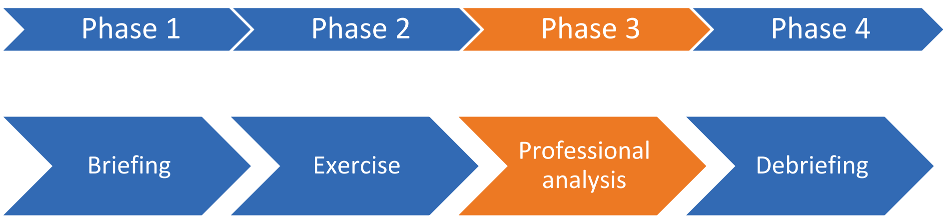

Figure 1. Phases of simulator instruction. The focus of this article is the work carried out by operators and facilitators during Phase 3.

Our research builds on the assumption that the teamwork of operators and facilitators, as well as the activities they engage in during simulations, should not be perceived as passive backstage activities of little relevance for the success of simulations as professionally relevant contexts for learning. On the contrary, their analytical gaze and their contributions to building and enacting know-how during simulation activities, are decisive for the outcomes and for the learning experiences of students during all phases. An interesting feature of simulations is precisely that they provide rich opportunities for following a range of significant learner activities, including how learners physically engage in health care practices, how they document their conceptual understanding when diagnosing patients, and how they communicate with patients and amongst themselves. Thus, operators and facilitators are in a position where they can both follow the delivery of care in detail in real time and consider the solutions students suggest and the difficulties they run into.

Consequently, over time, the team of operators and facilitators develop first-hand insights into how to guide and evaluate student activities during simulations.

Thus, this study aims to use video documentation of the concrete work of operators and facilitators during ongoing simulation training sessions to analyse the nature of their work and their contributions to the progress of simulations as environments for learning (Phase 3, Figure 1). Put differently, the novelty of this article is our focus on the analytical gaze that operators and facilitators develop as a team in order to support learning and evolution of the simulation exercises. By examining the activities of these actors, our contribution to the field of educational sciences is that we can begin to better understand how the process of enacting professional know-how in healthcare is conducted and evaluated during the entire practice of simulations, and not only during debriefings. Analytically, we can investigate the agency that the different elements of the activity, students, the instructors (operators/facilitators), and the technologies, exert in the co-construction and development of learning experiences.

In addition, one interesting element of simulations as contexts for professional learning that should not be overlooked is that they increase our capacities for understanding the details of how students/learners appropriate and exercise their know-how in a performative sense. What students do and say in situ provides clues to their know-how in response to challenges in healthcare practices (Wiig & Säljö, 2024). Thus, from the perspective of evaluating learning, and in comparison to either paper-and-pencil tests or oral testing, simulators offer an environment for studying how participants *enact* their know-how in challenging situations, and this enactment can be documented, analysed and assessed in real time as well as retrospectively through video documentation (Chue et al., 2022; Sellberg et al., 2022). By analysing simulations, operators and facilitators (and researchers) gain access to the conceptual (explanations, diagnostic reasoning, etc.), physical (use of equipment, handling of patients etc.) and collaborative actions that students engage in as they handle the challenges of the exercise.

Another significant feature of this mode of organizing learning and instruction is that it relies on intimate continuous coordination between human agents and technologies, digital as well as physical. The assumption of this analysis is that the technologies exert agency in the sense that they build on the use of representations (documentation) and physical artifacts (manikins, medical equipment for interventions, etc.) that guide the work performed. These resources have a long history and have been designed on the basis of institutional experiences of providing care. Through their design and use, these resources contribute to the progression of the simulation and to the agency of all those involved. From a sociomaterial perspective, the agentic elements of technologies in social practices must be recognized as essential for understanding the nature of professional practices and for learning such practices (Fenwick, 2014; Hawley, 2021; Hutchins, 1995; Mäkitalo, 2016).

In the following, three questions will be addressed: how do operators and facilitators (a) describe, analyse and assess features of the students' delivery of care, (b) monitor the progress of the scenario, including the function of the technology in these activities, and (c) comment on their own contributions during simulations. Thus, our focus is on the gaze of operators and facilitators as professional teams during simulations, the ways in which they build knowledge about simulations and decide on how these can be made more relevant as learning events. This multilayered nature of professional expertise implies that both the operators/facilitators (humans) and the technological resources serve as agents that co-determine the outcomes of simulations as contexts for learning.

2. Simulations, Learning and Feedback

2.1. Conceptual and Theoretical Background

The theoretical background of the research to be reported here is in a sociocultural and sociomaterial perspective, emphasizing the role of cultural tools/instruments—material and symbolic—in learning and development (Vygotsky, 1978). Cultural tools serve as "mediational means" (Wertsch, 2007) in human activities, and they play a crucial role in accumulating know-how and in building up a "cultural memory" (Donald, 2018) of solutions to problems previously encountered. By appropriating cultural tools, which may be intellectual (linguistic, conceptual, models), material (stethoscopes, reflex hammers) and/or both (heart rate monitors, digital surveillance instruments), novices appropriate professional know-how by means of which they will be able to exercise professional duties within an institution (Vygotsky, 1981). Simulations thus may be understood as resources for exposing novices to challenging situations mediated through technologies, and in which they should be able to appropriate know-how and learn to use the tools (physical/conceptual/procedural) of their profession.

In our analyses, we emphasize the value of attending to the participants' perspective on how they engage in simulations. Thus, our aim is to unpack (see below) what operators and facilitators do as they analyse and intervene in simulated environments when scaffolding and evaluating student work, and when attempting to improve simulations and increase their relevance as a context for learning healthcare know-how.

Simulations, when well designed and realistic, represent an important mode of learning and documenting professional skills as well as the evolution of such skills in situ. Such pedagogical activities are generally organized in a structure which includes (a) a written scenario, (b) an introduction to students of the agenda and learning goals (briefing), (c) an exercise (with, in our case, operators/facilitators present), and (d) a debriefing session. The latter is central from a learning point of view, it is "the heart and soul of simulator training" as Rall et al. (2000, p. 517) put it. During debriefings, participants can share experiences of the session, and they can reflect on and learn from their own actions/mistakes as well as from those of their fellow students as these are discussed; video documentation may also be present during such sessions (Gormley & Fenwick, 2016). But, in our view, it is obvious that operators and facilitators also learn and develop professional expertise as they engage in simulations. Phase 3 (Figure 1) has both retrospective (analysing the simulation in question) and proactive (preparing for the debrief and for future improvements of the simulation) elements and is a central site of learning.

2.2. Simulations as Contexts for Learning in Healthcare: Contributions by Operators and Facilitators

There are few studies exploring how facilitators and operators contribute to simulations as teams and how their interventions guide student learning in this technology-saturated environment. While a growing number of studies is investigating learning outcomes and debriefing effectiveness, as well as providing recommendations for how to conduct effective debriefings using quantitative post-hoc methodologies, relatively little is known about the details of the so-called "backstage" teamwork of operators and facilitators during simulations (Wiig & Säljö, 2024). Most studies which include observations on how these actors contribute to simulations concern the debriefing phase (4) only.

In the simulation literature, there are meta-analytical studies mentioning the facilitator role during debriefings as a variable generating learning effects. Keiser and Arthur (2021), for instance, discuss how facilitation approaches contribute to the effectiveness of the debriefing in teams versus at the individual level, concluding that "the most effective combinations being the self-led facilitation approach coupled with a team-aligned AAR [after action review], and the self-led approach coupled with objective media" (p. 1007).

However, these conclusions are rather abstract, and the authors do not go into details about how and in what ways operators and facilitators contribute in a functional sense. As Lymer and Sjöblom (2024) point out in their review of debriefings in various professions, "the precise nature of instructor behaviors that may influence learning outcomes is little understood" (p. 5).

The first comprehensive review of research that pays attention to the facilitator role was conducted by Tannenbaum and Cerasoli (2013). The authors, who focus on the debriefing phase, analysed 46 studies across professions where simulations are widely used, such as aviation, healthcare, military and organizational work. When examining the factors that contribute to the effectiveness of debriefing, Tannenbaum and Cerasoli argue that facilitation, structure and multimedia are widely thought to improve the quality of debriefs: "we found that facilitated debriefs (d = 0.75, or 27%) were about 3 times as effective as nonfacilitated debriefs (d = 0.25, or 10%)" (p. 239). In the conclusion, they argue that "it appears that facilitation helps, but the sample size for unfacilitated debriefs was too small to fully remove ambiguity" (p. 240). Consequently, the focus on best practices and guidelines for practitioners points to the predominantly normative knowledge interest in the debriefing setting in these studies. This implies a lack of attention to the details of how and why facilitators and operators intervene, and how they use and develop their professional expertise as support for learning as simulations unfold. The work of these expert teams, which is essential for the quality of simulations as learning events, are "black-boxed" (Latour, 1999, p. 304) rather than unpacked in such research.

Focusing on research structured around the role of interactions in simulations, Lymer and Sjöblom (2024) reviewed studies across aviation, healthcare and maritime education which make use of video-based methodology and document interactions as they occur in simulations. In the studies reviewed, facilitator guidance was highlighted as a central part of simulation practices, and the authors also point to the variety of ways in which guidance is exercised. The conclusions show the significant role of facilitator contributions to debriefings. This includes issues of how facilitator questions guide and steer the students' perceptions of their own performance during the post-exercise reflections (Johansson et al., 2017), how facilitators use story-telling about lived experiences in debriefing settings to relate simulator experiences to the realities of work in maritime education (Sellberg & Wiig, 2020) and, finally, how facilitator guidance focuses embodied actions at a detailed level in aviation post-simulation debriefing (Roth, 2015). We argue that it is important to explore the teamwork of operator and facilitator activities during the simulation and during all phases (Figure 1), i.e., Brief—Exercise—Professional analysis—Debriefing, in order to understand how simulations unfold and support student learning.

With respect to the operator role, most studies in healthcare research mention the role of the operator as a technical expert running the simulator, while the major focus of the few studies that include these experts in their analysis is on the activities of the facilitator. The few studies which engage with the instructional significance of the operator contributions point to how student performance during a simulated scenario is linked to the operator's pedagogical competence and technical expertise. At the same time, they highlight the need for more research on the operator role as a critical factor for the success of simulations (see, e.g., Waxman et al., 2019; Tamilselvan et al., 2023). Researchers also call for additional studies on effects, best practices and evidence-based guidelines to develop effective operator tools conducive to supporting learning (Gantt, 2012). For instance, Reierson et al. (2024) explored nursing students' perceptions of the operator's interpretation of the patient role during simulations and underlined that students had a limited understanding of the operator's pedagogical role.

In sum, the research reviewed above demonstrates differences in both facilitator and operators' roles in simulations and shows that there is a need for in-depth knowledge, exploring the contributions of these expert roles and their teamwork during simulator-based instruction. An interesting observation is that, to the best of our knowledge, no studies investigate the professional conversations and collaborations between teams of operators and facilitators during nurse care simulation exercises. Thus, and to sum up, the novelty of this study is the assumption that qualitative studies complement quantitative studies by analysing and detailing the teamwork of operators and facilitators as they engage in reflecting on the progress of the simulation and its instructional relevance. During this process, this study shows that operators and facilitators fine-tune their contributions during scenarios to support student learning while interacting with the manikin and other technological artifacts present in simulator laboratories. The contribution of this study is to provide contextualized descriptions of the details of the concrete work done by teams of operators and facilitators during ongoing pedagogical processes documented through video recordings. Thus, we seek to unpack the work done and its role for the unfolding of the simulation as a learning event.

3. Method and Data

The design of this study is inspired by interactional ethnography (Skukauskaite & Green, 2023) using video to document professional practices and discourses in healthcare. For this study, we observed two operator rooms in an advanced full-scale Nordic simulator laboratory to capture how the participants, operators (n = 6) and facilitators (n = 10), articulated their expertise as part of the simulator instruction. The data were generated in a compulsory simulation course in Basic Nursing. The recordings were made before the students' first clinical placement in medical units at hospitals, i.e., in terms of clinical experience the students are novices. Students were divided into groups of 6–10 participants, and they were engaged in a total of six different scenarios over a two-day period. The scenarios focused on patients with deteriorating health conditions, such as hypoglycaemia, cardiac arrest, postoperative bleeding and angina pectoris. In each scenario, from two to three students acted as nurses, while the other students in the group acted as family members or observers. The learning outcomes included assessing how students prioritized relevant nursing actions for clinical assessment, leadership and decision-making. They were obliged to implement care procedures such as the airway, breathing, circulation, disability and exposure approach (ABCDE) to determine basic physiological values of the patient in pain, to execute clear leadership by using Close Loop for effective communication, and to manage the health-care intervention related to Identification, Situation, Background, Analysis and Advice (ISBAR) to ensure quality and patient safety. Thus, what they were intended to learn are the mediational means used by professionals in specific care situations. The data included below in this article are from two scenarios, heart stop and postoperative bleeding.

The simulation follows the pattern described in Figure 1. Each simulation lasted about 2 h and started with a briefing session in which the facilitator introduced the patient case, the equipment necessary for handling the exercise and the learning goals. The simulated scenario lasted 15 min. After watching the video of their own performance (15 min), the student group engaged in a collective debriefing that lasted 50 min. This session was led by the facilitator following the PEARLs script.[1]

The data for this study capture the reflections and analyses by operators and facilitators (Phase 3) as they prepared for the debriefing (Phase 4). The object of inquiry of our research is the activities of these professional teams as they reflected on what they saw during Phase 2. The recordings were made in the control room and lasted approximately 15–30 min each.

In total, 30 conversations, comprising approximately 15 h of video recordings, were generated. In addition, observation-logs, photos, and other artifacts, such as assignments and students' observation-schemes, were collected. One camera with a wide-angled lens was placed in the corner of the operator's control room to capture the digital equipment, such as screens and touch-panels for steering the manikins, and the interactions between the operators and facilitators during their conversations. A separate microphone at the desk secured high quality sound recordings. See Figure 2.

Figure 2. Illustration of the video- and audio recording of the operator room.

It should also be mentioned that each simulator suite is equipped with three wide-lens video cameras and one separate microphone that document student work. One of the cameras captured the whole room, another camera was placed over the hospital-bed to capture the detailed interactions between manikins and students, and one wide-angle camera was turned towards the observing students. The operators and facilitators used the 360 degree camera installed in the simulator suits to follow student activities. These recordings were the video documentation that operators and facilitators accessed as they analysed the simulator sessions. We should also point out that the operators and facilitators in this centre had professional backgrounds as nurses and extensive experiences of care and simulations.

The project was approved by the National Department of Ethics. All participants volunteered and signed an informed consent form. All personal information has been anonymized.

4. Results

4.1. Analytical Procedures

The material has been analysed through the lens of a sociocultural conceptual framework and by using interaction analysis (Jordan & Henderson, 1995). For this analysis, all the conversations among operators and facilitators were transcribed and subjected to collaborative analysis. Data were analysed in several data sessions involving the authors as well as in data sessions involving a more comprehensive research group that comprises a network of researchers from different disciplines working with interaction analysis of video-recorded data (cf. Heath et al., 2010). Preliminary findings were also presented at the American Educational Research Association 2024, receiving valuable recommendations to further elaborate and finetune the analyses (Wiig & Säljö, 2024). The three episodes selected for this article were transcribed at an intermediate level to allow researchers in professional learning and instruction environments in healthcare to follow the conversations and activities (Linell, 2011).

The video recordings, which documented the post-simulation analyses by operators and facilitators, were analysed, and three particularly interesting areas of participant concerns emerged. These areas imply that the teams of operator and facilitator were:

(a) *calibrating observations and interpretations made during the simulation exercises.*
Here, the operators and facilitators describe and analyse central features of the students' delivery of care in order to calibrate their individual observations and interpretations. The work done here serves to reach an agreement on what has evolved during the simulation and decide what needs to be communicated to students during the debrief. Assessing student performance and what has been demonstrated in terms of professional know-how, are central features of this work.

(b) *monitoring the progress of the scenario as an instructional event.*
This involves considering (1) the use of the technological tools available during the simulation exercise, (2) attending to student activities and (3) the work by the operator in the operator room when monitoring and guiding the on-going simulation. Evaluative statements are part of this activity as well.

(c) *commenting on their own contributions.*
Operators discuss their experiences acting as patients, doctors, etc., during the simulation exercise. This discussion included the normative ambitions of operators and facilitators to improve the simulations as contexts for learning and how well they succeed in supporting student learning.

The nature of these three types of professional analyses during Phase 3 will now be described in some detail.

4.2. Calibrating Observations and Interpretations Made During the Simulation Exercises

Delivery of care is a complex undertaking, and students engage analytical, communicative and physical activities that operators and facilitators have to analyse and evaluate. The following excerpts have been collected from conversations between two experienced participants, one operator and one facilitator, during the Heart Stop Scenario, a common simulation exercise. This is a stressful exercise for the students where they have to rescue the manikin's life, and the operator and facilitator follow student work and look at the digital monitors providing data on the medical condition of the manikin/patient. One of the central issues of providing care in this emergency situation is the depth and intensity of the pressure exerted on the manikin's chest. The operator can monitor the frequency (1–100%) and depth (1–10 centimetres) of correct heart and lung compressions through digital monitors of vital measures while simultaneously following the video documentation of student performance. On the monitors, correct procedures with respect to pace and depth of compressions are displayed in green colours and incorrect are in red. In Excerpt 1, we see how students struggle during this exercise, and we also see the detailed observations that the operator and facilitator make as they review student performance. See Figure 3:

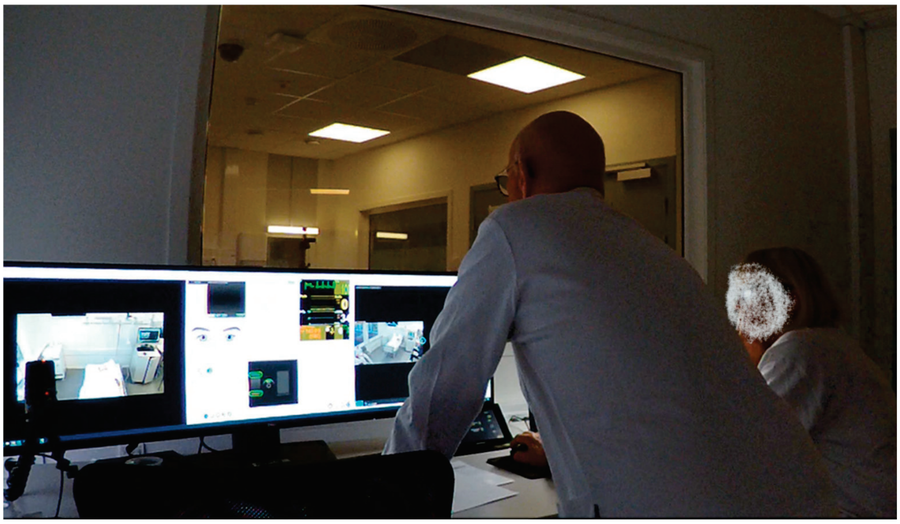

Figure 3. Illustration of operator and facilitator reflecting over observations from the Heart Stop Scenario.

Excerpt 1. Heart Stop

1. OP it will be interesting to see if they say something about it themselves

2. because his [compressions] [Stephen] were uhm maybe 3 max 4 cm about only halfway down

3. because the frequency was ok uhm [

[The OP points towards a screen where the monitor displays depth and frequency and while watching the video of the nurse students in action]

Compression, frequency and depth: 1–10 centimeters. Red and green colors for correct procedures

4. FAC [yes (.) was the frequency [of heart compressions] satisfactory?

5. OP yes (.) it was a bit [

6. FAC [yes (.) was he a bit slow?

7. OP yes (.) he was a little slow (.) but he was like uhm (.) all the way down to (.) well probably around 100 [percent in depth]

8. FAC oh really? at that level (.) okay that [makes notes for the debrief]

9. OP exactly (.) because it was just uhm

10. he was lying right on the border between 100

11. uhm on the green field [points to the monitor indicating frequency] and down towards what was the margins

12. FAC and Sarah? she wasn't deep enough either (.) was she?

13. OP no she wasn't deep enough either

14. FAC no none of them (.) neither Sebastian nor Sarah was

The nurse students struggled in different ways to give the manikin correct heart and lung treatment. In the first line, the operator says, it will be interesting to see if they say something about it themselves, thus anticipating the upcoming debrief session, and if students are aware of their difficulties in performing CPR (cardiopulmonary resuscitation) correctly. According to the operators' in situ observations of the monitor for vital measures, Stephen was maybe 3 max 4 cm, or only halfway down, but the frequency was ok (lines 2 and 3). Figure 4:

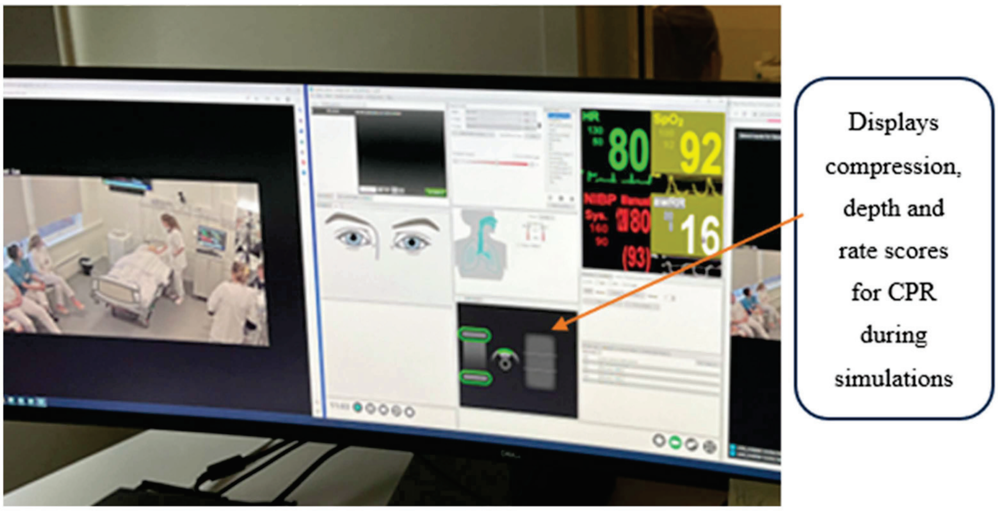

Figure 4. Illustration of the monitor used by operators and facilitators.

The facilitator asked two questions to address her concerns based on her observations during the exercise: `Was the frequency satisfactory?` (line 4) and, more precisely, `was he a bit slow?` (line 6). Noticing differences, the operator confirms her observation that Stephen `was a little slow` but underlines that the compressions scored almost 100 percent in depth, as was shown by the monitor (line 7). Somewhat surprised, the facilitator `replies Oh really! At that level!` (line 8), and she makes notes for the upcoming debriefing. The operator further explicates, by referring to the monitor: `he was right on the border between 100, uhm on the green field and down towards what was the margins` (lines 10 and 11). The analysis continues in lines 12–14, when they highlight how the other students act by saying, `and Sarah? She wasn't deep enough either, was she? No, none of them.` These utterances demonstrate the ways the operator and the facilitator jointly negotiate their interpretations of the observations made. Together they calibrate and fill in missing information in their analyses of what is going on, and they have access to the technical mediation of the activities from the medical monitors. Thus, the situated calibration is tightly connected with their professional experience in nursing, their professional vision (Goodwin, 1994), and the simultaneous consultation of technical devices. In this sense, the assemblage of operator/facilitator and the technologies exert agency in the situation resulting in a detailed analysis of the progression of the provision of healthcare.

4.3. Monitoring the Progress of the Scenario as an Instructional Event

A simulation is a dynamic event. Even though there is a scenario based on a well-considered script, the activities of students are decisive for the progress and the relevance of the exercise. In response to the students' initiatives and performance, operators and facilitators have to be creative to keep the exercise on track towards the intended learning goals. Excerpt 2 is from a conversation between a trainee operator (OPT), an experienced operator, and the facilitator in a scenario referred to as Postoperative Bleeding. The learning goals include engaging in systematic patient observation (ABCDE-procedure) to assess a deteriorating/critically ill patient with a bleeding wound, and to keep the patient alive.

The operators and the facilitator monitor the progression of the scenario as an instructional event and jointly reflect on its instructional relevance for the students. They discuss how to trigger students to perform expected procedures, such as checking blood pressure, in a post-operative scenario setting. They are well acquainted with the design of the scenario and the learning goals central to the exercise, but they are also continuously responsive to the nature and quality of activities that the students engage in. In the following excerpt, the facilitators discussed how they could manipulate the technical features of the manikin with a bleeding wound and intervene through triggers to support students, who showed a lack of understanding of what to do in a critical postoperative care situation (cf. Figure 5).

In this excerpt, the operators and the facilitator were concerned, even perplexed, that the students did not seem to notice the significance of blood pressure in a post-operative bleeding setting. Monitoring the students' obvious lack of knowledge regarding the importance of examining the manikin's circulation (to check for possible blood loss), they jointly reflect on why students failed to attend to this. One explanation is lack of knowledge on the part of students, but the other alternative they consider is if they should have manipulated the medical digital technologies to provide students with sharper clues to check vital measurements during the exercise. Thus, they turn their attention to the interrelationship between the simulation and their own contributions. The operator trainee calibrates her observation with the team: `you adjusted the pulse down to emphasize the thing about painkillers` (lines 2 and 4). The operator confirms, and the trainee explicates her reasoning by pointing to the monitor while saying `then I thought, if one were to somehow highlight the issue of post-operative bleeding so maybe the heart rate could have been high and the blood pressure low to follow that track a bit more` (lines 5, 7, and 9). Suggesting how to highlight the instructional goal of the scenario, the team members discuss how to finetune the technical indicators to steer students into understanding how to perform the correct procedures by checking the circulation of a bleeding patient. They realize that the students did not understand the point of the simulation script, underscoring that `we can make slightly more visible triggers on that` (line 12). Consequently, the professional team highlighted that, if the operator provides more obvious technical triggers on vital measures, the facilitator can bring it up in the post-simulation reflections; this would be `something to elaborate on during the debriefing` (line 13) in order to reach learning goals. Commenting on the fact that students do not follow the to-do list of the ABCDE-procedure, the operator admitted that the scenario and the instructional design do not properly support students' performance because `they simply do not relate to C` (line 14), i.e., circulation.

The practical instructional problem for the operators and facilitator is how they can make the significant details of the scenario salient for the students through technical as well as human interventions. The suggestion they make, to provide a more relevant instructional event in the simulator suite, is to redesign the situation by (a) having the operator provide clearer triggers, and (b) changing the technical parameters visible on the monitors in the simulation suits. This kind of "backstage" work thus involves using experience and know-how from current simulations, the technical equipment and the professional clinical expertise to improve the instructional relevance. In this sense, the team members recognize the problems of the agency of the various elements in the simulation. The scenario was not clear enough, and neither the technology nor their own interventions provided sufficient triggers. This is a comprehensive and very detailed analysis of the work carried out by these expert teams in an instructional situation and its apparent failure to promote professional learning. The analysis by the experts, furthermore, considered the many levels involved (scenario, technology and human intervention).

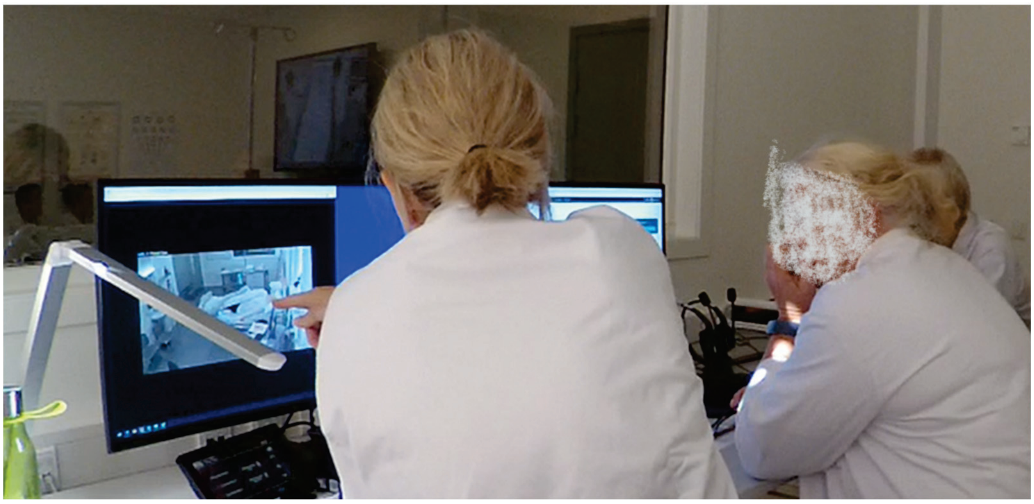

Figure 5. Illustration of operators and facilitator reflecting over the Postoperative Bleeding Scenario.

Excerpt 2: Postoperative Bleeding

```
1.  OPT   considering the vital measurements  [visible at the monitor]
2.  OPT   you adjusted the pulse down [
3.  OP                                 [yes [
4.  OPT                                       [to emphasize the thing
          about painkillers (.)
5.        then I thought if one were to somehow highlight the issue of
          post-operative bleeding [
6.  FAC                             [yes [
7.  OPT                                   [so maybe the heart rate could
          have been high and the blood pressure low?  [pointing at the screen of
          the monitor]
8.  OP    yes we certainly could
9.        yes [uhm
10. OPT       [to follow that track  [of the scenario]  a bit more?
11. OP    yes m:
```

The conversation continues and ends with the following conclusion:

```
12 OP     but we can make slightly more visible triggers on that
13        yes because then there is something to elaborate on during
          the debriefing [
14 OPT                   [the issue about ABCDE (.) because they
          simply do not relate to C [
15 OP                               [no they don't and it's pretty far
          up on the to-do list  [of ABCDE-procedures]
```

4.4. Commenting on Their Own Contributions as Participants When Acting as Patients

The final transcript is also from the scenario Postoperative Bleeding, but a new student group was involved. During the scenario, the students noticed a bleeding wound, but they did not respond by performing the correct clinical procedures in the care situation (similar to what happened in Excerpt 4b). By externalizing their observations, the operators and the facilitator shared their reflections on their own contributions acting as the patient in pain, as doctors, etc., during the simulation exercise, and they evaluated if the students' actions were satisfactory when responding to their prompts. We enter the conversation while the trainee operator, acting as the doctor in the scenario, shares her observations of her own contributions and reflects on how to improve the scenario and the instruction. She suggests allowing the doctor to use some additional prompts related to the bleeding wound earlier in the script/scenario to make it more obvious for students that they have to check the blood-soaked bandage and perform the expected clinical assessment in the care-situation. This opens a normative evaluation of the instructional relevance of the entire scenario, discussing how to provide triggers, changes in their role-play and how to fine-tune their own work to improve the simulation as a context for learning (See Figure 6):

Figure 6. Illustration of operator and facilitator reflecting over the documentation of Postoperative Bleeding Scenario.

Excerpt 3. Postoperative Bleeding

1. OPT additionally I also think that in that doctor's consultation

the doctor [the operator] could have asked about it [to check the wound] a little earlier perhaps

2. FAC m:

3. OPT to get them onto that track [perform correct clinical procedure]

4. FAC m:

5. OPT because it is actually a part of the scenario [

6. OP [yes mm

7. FAC after all they didn't even think about it [

8. OP [no

9. FAC they didn't think of bleeding at all did they?

The conversation continues and ends with the following conclusion

10. OPT no but we make a couple of such changes here

and then we'll see if we [uhm

11. OP [yes let's see if we get some response on that (.) it will be interesting

12. OPT yes, isn't it like that eh that's how learning [to simulate] is

back and forth.

13. FAC mm

14. OP anyway compared to previous groups (.) because we weren't supposed to have so much intervention from us

still maybe we can uhm we can reverse [the scenario]

that's perfectly fine

15. OPT yes because there is something in a normal situation (.)

to trigger them [the students] a little more to intervene

give some liquid and eh maybe they can take another blood pressure (.) and call the doctor a little sooner

16. FAC if they are concerned that there is bleeding (.)

they call [the doctor] promptly

17. OPT now it seems that nothing is very urgent

Here, the operator trainee suggests that, `in that doctor's consultation`, the operator, acting as the doctor, `could have asked` students if they should have examined the patient's body `a little earlier` (line 1) during the simulation. The idea is to get students `on to that track` (line 3) of checking a surgical wound and start efficient treatment when blood soaked through the bandage, which was a central `part of the scenario` (line 5). The instructors realize that the students do not understand the point of the script/scenario/exercise; `after all, they didn't even think about it` (line 7). The facilitator, observing the students during the exercise, confirms the evaluation and responds with a rhetorical question, `they didn't think of bleeding at all did they` (line 9).

This led the team into discussions about their ambitions to improve the simulation as a context for learning these clinical skills. Consequently, they agreed that, to improve the scenario, `we make a couple of such changes` (line 10) to explore `if we get some response on that (.) it will be interesting` (line 11). Arguing that to improve the simulation moving back and forth is part of the continuous professional process of fine-tuning the simulation in relation to various student groups, `that's how learning is` (line 12). Such a revision is also necessary in order to prepare students for situations they will encounter in their future working lives. Creating connections to `a normal situation` (line 15) in a hectic intensive hospital department, the trainee operator suggests several activities to revise the scenario to create realistic tasks `and to trigger them a little more to intervene`, since they should realize that they have to `give some liquid, take another blood pressure and call the doctor a little sooner` (line 15). The goal is to make the students aware of the urgency of this kind of situation. The facilitator agrees agreed and underlines that, in the daily life of nurses, it is important to recognize that `if they are concerned that there is bleeding (.) they` [should] `call` [the doctor] `promptly` (line 16). Together, the team members agree on the necessity of making students realize the significance of immediate action in that type of situation. The professional agenda behind this argument is that operators and facilitator are concerned that the students are acting as if nothing `is very urgent` (line 17) in the situation. The message they wanted to send is that, in situations of this kind, immediate action is expected.

The practical problem for the operators and the facilitator in this situation is similar to what we saw in Excerpt 1b) above; however, here they are commenting on their own contributions when acting as doctor, patient, etc., and considering whether these interventions provided enough information for the students to act on. Thus, the transcript document how the experts evaluate and calibrate their professional understanding of how their interventions co-determine several aspects of students' performance. This concern matters in terms of how they as operators/facilitator initiate actions, notice variations in how individual students respond to them, and monitor the students' actions to conclude whether they are too slow or not adequate. Thus, what they realize is that student performance of their know-how is, to some extent, relative to their own contributions during simulations.

The simulator technology allows a simulation to be continuously monitored by experts who are watching how students engage in meaning making while confronted with challenges. When they realized that the students do not perform the core elements of the scenarios in expected manners, they discussed possible interventions to remedy the problems preventing students from understanding the situation. Thus, the simulator team used their clinical experiences and know-how from emergency hospital wards, the technological equipment available and their expertise in simulations to improve students' understanding/awareness of the nature of the situation, i.e., they want to get the students on to that track (line 3). In this sense, the team members recognize the problem of the agency of their own contributions when they performed the roles of doctor, relatives and patient in pain. They reflect on the point that students might know the correct procedures of what to do, but the problem is the relevance, or lack of, of the operators' intervention. Put differently, the members of the team are uncertain if they appropriately triggered students' understanding of how to make use of their experiences and possible know-how in the simulated situation.

Taken together, the empirical analyses show the significance of the role that operators and facilitators played for how simulations unfolded. They were active at several levels, as evaluators of student performance, analysts of how the scenario and responsible for the technology, and evaluators of their own contributions to the learning event. Outcomes of this kind of work are part of what the simulation is all about as a learning environment.

5. Discussion

In this study, we have scrutinized the contributions by operators and facilitators as professional teams as they engage in and develop simulations. We have shown how operators and facilitators reflect on the progress of the scenario, its instructional relevance and their own contributions to further develop simulations to create even more powerful learning settings. The goal has been to show that the "backstage" team activities are significant instances of professional learning while simultaneously improving the simulations' instructional value.

The operators and facilitators reflected upon how the simulation, including the scenario, technology, student work and their own contributions, function as a coherent context for student learning of professional know-how. The problem they encountered was that the agentic elements of the scenario, the technology and their own contributions, all of which are intended to put the students on track, were not working as expected. One of the issues they struggled with was how the technologies and care situations they exposed students to sometimes seem to lack clarity or transparency for the students. When attempting to understand the roots of these elements of the simulation, a dichotomy of contrasting interpretations emerged among operators and facilitators. One reflection made when the simulation did not unfold according to expectations was that the students did not understand what to do in the scenario, and that this could lead to the difficulties observed. In that case, the conclusion was that students were not familiar with expected care procedures. At the same time, when facing cases in which the simulation does not work according to expectations, they suggested that the simulation technology was not transparent for the students, that is, they considered whether the problem was in the simulation and their own contributions, rather than in student knowledge. Consequently, they considered the problems that they observed from two perspectives. Either the students' knowledge was below expectations, or, alternatively, the simulation did not work as intended because of the way in which the care situations were rendered by technology. These reflections on the nature of the problems they observed are formulated in a series of reflections regarding the dilemma of how clear the technology must be when presenting challenges, what they have to do when they intervene, and what students have to know in order to be able to respond with relevant care procedures.

The ways in which the expert teams reflect on student learning illuminate the disparities in perception between a professional and a nursing student when faced with a specific care situation. For instance, a bloody and wet bandage serves as a stimulus that a professional, equipped with patient experience, clinical expertise, and know-how, would instinctively respond to in a predictable manner. However, a stimulus does not necessarily prompt one specific action; rather, the response and the resulting action are contingent upon what you are looking for and what you are able to see in the situation. Consequently, the operators and facilitators realized that the bloody bandage, although a potent stimulus for a professional, fails to trigger the anticipated responses from the novice students. These students *de facto* observed the bloody bandage but failed to grasp its significance within the scenario. In other words, their perception, understanding, reaction and enacted response differ markedly from those of experienced professionals when confronted with a situation of this kind. Through their analyses, the experts attempted to consider how to modify the situation and the technology in ways that could recalibrate how students perceived the situation. They sought to design the simulation in such a way that students saw the bloody bandage through a new lens as a sign of a severe situation that required an immediate response. This process underlines the profound transformative potential of simulations—reshaping not only what students know about healthcare in general sense, but also how they will be able to see what they are facing through a professional lens. In other words, the concerns are how to improve students' professional vision (Goodwin, 1994).

Operators and facilitators continuously discussed the effectiveness of scenarios and their relevance for professional learning, analysing student performance, their own contributions and the affordances of the technology in the learning situation. However, the agency of students in a situation relies on training to see and understand what the implications are of what you see. Therefore, the use of procedures and methodologies such as ISBAR, ABCDE or Close Loop must be trained, not just as instrumental techniques, but as ways of seeing something from a professional perspective. When reflecting on how to make students relate to the C (Circulation) of the ABCDE-procedure (Excerpt 2), they wanted students to understand *how* and *why* using systematic ways of determining basic physiological values of a patient in pain is vital and urgent. However, the simulation did not make students notice the significance of blood pressure in post-operative bleeding, and in response, the experts reflected on their contributions, contemplating various strategies of how to improve the scenario to get students on track. Thus, our findings suggest that there is an accumulation of professional judgement and learning as teams of operators and facilitators continuously attend to, including clinical, pedagogical, technological and simulation-specific issues.

6. Conclusions

By analysing the gaze and the initiatives of operators and facilitators during simulations, our study makes an original contribution to the existing research on the "backstage work" of these teams. Our study provides a new understanding of the ways in which operators and facilitators build knowledge about simulations and how these can be made more relevant as learning events. The multilayered nature of professional expertise implies that both the operators/facilitators (humans) and the technological resources serve as agents that co-determine the outcome of the simulations. In line with research on interaction in simulator-based training, this study confirms that simulators offer an environment for studying how participants *enact* their know-how, and this enactment can be documented in its conceptual and material dimensions in ways which are not possible in most other settings.

7. Limitations

Our study has limitations that should be considered. First, the research was carried out in the "context of discovery" (Hanson, 1958), i.e., our knowledge interest was to unpack what is occurring in simulations and how they are structured as learning experiences. Thus, our assumption was that what operators and facilitators contributed could not be considered "backstage activities", as has been argued. Rather, the operators and facilitators exerted agency, and what they do, including the analyses they perform, were decisive for what students are able to learn. Second, we have chosen to focus our analysis on two scenarios in which the operators and facilitators work as teams, and do not explore the other four scenarios in this article. This is in line with the detailed level at which instruction and learning in simulations are analysed. Third, the simulator scenarios are regulated by certain structures and time frames that the participants might experience as being restrictive. Fourth, we also acknowledge that our analysis is limited to two control rooms located within the formal institutional context of one higher educational setting. Other professions and other institutions would provide additional information and other results. Therefore, we call for added in-depth and longitudinal studies on how teams of operators and facilitators structure learning and instruction in other simulator-based professions and higher education institutions.

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Notes

1 PEARLS debriefing framework by Eppich and Cheng (2015) means Promoting Excellence And Reflective Learning in Simulation. The PEARLS framework integrates three common educational strategies used during debriefing, namely, (1) learner self-assessment, (2) facilitating focused discussion, and (3) providing information in the form of directive feedback and/or teaching.

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Article

High Expectations During Guided Pretend Play in Kindergarten: A Promising Way to Enhance Agency in a Digitalized Society?

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Abstract: As digitalization and digital transformation shape developments in society, children's competence and agency for digital transformation need to be fostered from an early age. Equitable digital education is of utmost importance. Teachers' expectation behavior is relevant for providing equitable learning opportunities for all children. This study focuses on guided pretend play in digital education in kindergarten. This study examines whether high-expectation behavior of teachers is found in the behavior of kindergarten teachers during guided pretend play, and whether teacher expectation play behavior reveals different expectations for boys and girls. Video observations of guided pretend play in 15 kindergartens were analyzed using a qualitative cross-over design. While teachers interacted for equal durations with boys and girls during guided pretend play, significantly more incidents revealed teacher expectations toward girls than boys. Overall, high-expectation play behavior was less prevalent than low-expectation play behavior. In order to support further research and practice, an exploration of video sequences identified characteristics of teachers' high-expectation behavior for guided pretend play, such as holding back or enabling children's agency.

Keywords: agency; digital education; guided pretend play; kindergarten; preprimary school; teacher guidance; teacher expectations

1. Introduction

The Convention on Children's Rights includes the right to education, play, and participation (United Nations [UN], 1989). In 2021, the "General comment No. 25 (2021) on children's rights in relation to the digital environment" reflected children's rights in the digital age and emphasized the importance of children's evolving autonomy as well as the need for protection (United Nations [UN], 2021). Digital education should aim to enhance children's autonomy. For education, ensuring and enabling children's agency is paramount. For early childhood education, free play supports children's agency. Children's agency as global citizens is played out in early childhood, as children show an early understanding of the economic, social, and environmental dynamics of the world and seek solutions to various problems through pretend play (Kalessopoulou et al., 2023). (Young) children's agency can be defined as children acting independently and making choices (Engeness, 2021). For young children, agency means being respected by adults as social actors (Abebe, 2019) and being given opportunities to engage with them (Jerome & Starkey, 2022). In the context of digitalization, young children's agency is based on early digital education, thus constructing an understanding of the (digital) world. Ensuring children's agency is highly relevant for early childhood education, as early childhood education plays a significant

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role in shaping the future developmental and academic growth of children (McClelland et al., 2013; Pace et al., 2019).

As digital transformation is a core dynamic of current and future developments, it is crucial for all young children to experience agency in digitalization. Proficiency in digital technologies and active participation in shaping a digitalized society are becoming increasingly important in many everyday contexts and professions. For both girls and boys, it is crucial to develop an early interest in professions within the field of information technology. Pretend play offers a valuable opportunity to do this (Turja et al., 2009). For early childhood education, one promising way to encourage children's agency in a digitalized society is through guided pretend play, which allows children to imagine being in control of digital technology (Arnott et al., 2020; Bird, 2020; Vogt & Hollenstein, 2021), act independently, and make choices.

Guided pretend play allows for both children to initiate ideas and direct the activity, as well as early childhood teachers to be involved in play (Skene et al., 2022; Zosh et al., 2018). Guided play is more effective for young children's learning in some domains compared to free play or direct instruction (Skene et al., 2022). When involved in play, the teacher interacts continuously with the children. The analysis of teacher–child interactions [in the context of school] revealed that teachers' behavior toward their students can vary based on their expectations (Brophy & Good, 1974; Finn, 1972; Ludwig, 1991; Wang et al., 2018). Through teacher–child interactions, teacher expectations become evident and affect children's self-concept and achievement (Denessen et al., 2022; Wang et al., 2018). The problem is that teacher expectations can be biased (e.g., based on gender, socioeconomic status, or migration background; Gentrup & Rjosk, 2018; Wang et al., 2018). Teacher–child interactions have the potential to reinforce gender-biased expectations; for example, teachers commenting on girls wearing pretty clothes or being helpful, and on boys' physical strength (Chick et al., 2002). The teacher's guidance in play can reveal teacher expectations, for example, regarding children's digital skills. Teacher's expectations have an impact on the learning opportunities provided to a child. In digital education, the risk of teacher bias in expectations is high (Wammes et al., 2022). Guidance based on biased expectations can hinder children's agency in digital education, as it can be strengthened or weakened (Jerome & Starkey, 2022).

Teacher–child interactions based on biased expectations can lead to inequality in education. Although teacher expectations have not yet been widely examined in early childhood education (Timmons et al., 2022), related social inequalities in the early years can lead to long-term disadvantages (Alvidrez & Weinstein, 1999; El-Hamamsy et al., 2023). Therefore, in order to provide equitable digital education and ensure that all children can develop agency in a digitalized society, teachers must provide equal learning opportunities and have unbiased high expectations for all children (Timmons et al., 2022). Providing equal opportunities in education remains a challenge (Erzinger et al., 2023)—especially in digital education (Wammes et al., 2022).

This paper explores the possibility of observing teachers' high-expectation play behavior during guided pretend play sequences on digital transformation in early childhood education and analyzes the difference in teachers' expectation play behavior toward boys and girls. Before presenting the materials and methods, the importance of guided pretend play to promote agency in a digitalized society, teachers' expectation play behavior, and its role in children's development and experience of agency during guided pretend play are discussed.

1.1. Guided Pretend Play to Promote Agency in a Digitalized Society

Digital competence has become a part of the curricula of compulsory education. Many countries in Europe have updated and published educational policies and curricula to embed the development of digital competence (Ferrari & Punie, 2013; Voogt & Roblin, 2012). The current curricula focus on competence in using digital media and specific aspects of computer science, such as coding. Skills such as a basic understanding of evolving digital technologies, their production, and repair, as well as issues regarding artificial intelligence, have received little attention in early childhood education (Friedrichs-Liesenkötter, 2019; Lienau & van Roessel, 2019). Not only competent use of digital technologies is important, but also transversal competence. Transversal competence (often called '21st-century skills') commonly refers to a set of abilities that include communication, collaboration, critical thinking, creativity, and problem-solving (van Laar et al., 2017). Therefore, children should be encouraged to experiment with technology and reflect critically and creatively on digital technology and digital transformation (Grassmann et al., 2022). Given the significant and rapid changes taking place in society through digital transformation, it is important for young children to make sense of these processes and experience their agency. Digital technologies are becoming increasingly important in many professions and everyday contexts.

As children explore in pretend play what society considers important (Hauser, 2013), guided pretend play is a promising way to encourage young children's agency in a digitalized society. Guided pretend play allows children to imagine being in control of digital technology (Arnott et al., 2020; Bird, 2020; Vogt & Hollenstein, 2021), act independently, and make decisions. Following this, guided pretend play is also a promising approach to encouraging the above-mentioned digital and transversal competencies (Hollenstein & Vogt, 2024; Vogt & Hollenstein, 2021; Vogt et al., 2020). For example, children can pretend to be in a certain role (e.g., an IT expert) and can pretend to manipulate objects without using them (e.g., pretending that a wooden object in the shape of a tablet is a tablet). Prolonged pretend play sequences allow for intense and playful interactions between the teacher and (a small group of) children.

1.2. Teacher Expectations and Teachers' High-Expectation Behavior

Teacher expectations are beliefs about children's current or future behaviors or achievements (Good & Brophy, 1997; Rubie-Davies, 2004). Teachers form their expectations based on previous student achievement, classroom behavior, and engagement, as well as demographic characteristics such as ethnicity, gender, socioeconomic status, and special education status (Dusek & Joseph, 1983; Rubie-Davies, 2009; Rubie-Davies & Peterson, 2016). These expectations can be influenced by subjective biases (Lorenz, 2018; Mienert & Pitcher, 2011). Teacher expectations become evident through teacher–child interactions (Denessen et al., 2022; Wang et al., 2018). A growing body of research suggests that teacher expectations can indeed strongly influence the learning opportunities provided to children, leading to equal or unequal learning environments (Timmons et al., 2022; Wang et al., 2018).

Following the Pygmalion study by Rosenthal and Jacobson (1968), numerous studies have been conducted to empirically examine the relationship between teacher expectations and their classroom behavior (Wang et al., 2018; Weinstein, 2002). Assuming that teachers behave differently toward their students depending on their expectations of students' level of achievement, Harris and Rosenthal (1985) described four behavioral clusters that reveal teacher expectations: (1) creating a socioemotional climate (climate), (2) providing differentiated and appropriate feedback on student achievements (feedback), (3) offering challenging instructional content (input), and (4) increasing the extent to which teachers provide opportunities for students to respond (output). Reviews and meta-analyses have identified "climate" and "input" as particularly important factors (Kunter & Pohlmann, 2015; Ludwig, 2010; Rosenthal, 1993). Rubie-Davies (2007) identified teachers who consistently held high or low expectations for all their students. Teachers with high expectations exhibited distinct behaviors, including treating all students equally, fostering a positive classroom climate, and supporting students during the learning process. Such teachers frequently reorganized students into flexible groups, regularly adjusted seating arrangements, minimized disciplinary measures, and provided clear objectives, progress monitoring, and feedback that promoted autonomy, development, and student achievement. In contrast, teachers with low expectations treated students differently and focused their feedback on behavior rather than the learning process. These teachers often group students into fixed-ability groups. They monitored some students more closely than other students during the lesson (Rubie-Davies, 2014). Subsequently, Rubie-Davies et al. (2015) investigated whether and how teachers can learn high-expectation behavior and analyzed its impact on student achievement. Coaching in high-expectation behavior includes the following four aspects: (1) focusing feedback on content rather than children's behavior, (2) providing cognitive activating input (e.g., asking open-ended questions), (3) giving students opportunities to respond (output), and (4) creating a warm learning environment/classroom climate. The results indicate that it is possible for teachers to learn high-expectation behavior. Children taught by teachers who had already received the aforementioned coaching had significantly higher learning gains in mathematics than children whose teachers had not yet received such coaching. This study focuses on teachers and students in primary and secondary schools (Rubie-Davies et al., 2015).

The theoretical assumption (Brophy & Good, 1970; Ludwig, 1991; McKown & Weinstein, 2008; West & Anderson, 1976), which is partly empirically confirmed (Gentrup et al., 2020; Harris & Rosenthal, 1985; Hollenstein, 2021; Rubie-Davies, 2014; Woolley et al., 2010), is that students are aware of different teacher behaviors (i.e., assessing achievement in feedback, level of difficulty of learning input) and integrate their perceived teacher expectations into their self-concept. Subsequently, self-concept affects achievement. Figure 1 shows the assumed relation between teacher expectations and children's digital competence in early childhood education in accordance with the theoretically assumed and (partly) empirically confirmed relation between teacher expectations and students' achievement in school (Brophy & Good, 1970; West & Anderson, 1976; McKown & Weinstein, 2008). Teacher expectations regarding children's digital competence consciously or unconsciously influence teacher behavior while interacting with children. For example, teachers may or may not provide opportunities for children to contribute to a digital technology topic. A teacher's consistent behavior (e.g., providing opportunities for children to contribute) may make their expectations visible to the children (Lorenz, 2018). Children integrate the experience, whether the teacher provides them opportunities to contribute to the digital technology topic or not, into their self-concept of being seen as capable of contributing to the digital technology topic or not). Children's self-concept in digital technology relates to their digital competence.

The empirically grounded observation of high-expectation behavior, as developed by Rubie-Davies et al. (2015) for schools, has not yet been transferred to early childhood education and guided pretend play. Biased expectation behavior was found in a study examining parents' play guidance when playing mathematical board games with their children (Moffatt et al., 2009). The results indicate that parents differ in their play behaviors between sons and daughters when they play board games with mathematical content. Both mothers and fathers encouraged sons more often than daughters to become active themselves when it came to mathematical content (Moffatt et al., 2009).

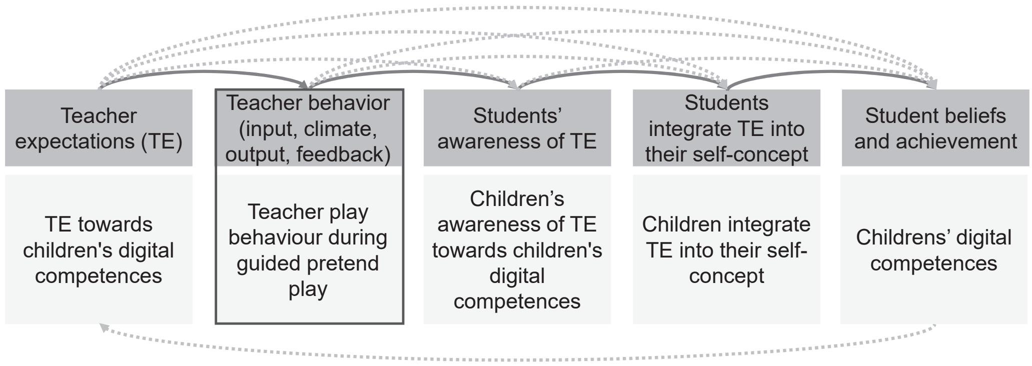

Figure 1. Teacher expectations and their relation to students' achievement (Brophy & Good, 1970; West & Anderson, 1976; McKown & Weinstein, 2008) adapted to expectations and digital competencies. Note. The dark grey boxes show the theoretically assumed and (partly) empirically tested relation between teacher expectations and student achievement in school. The light grey boxes below describe the assumed adaptation for guided pretend play in early childhood education.

1.3. Relevance of Teacher Expectations During Guided Pretend Play

Expectations help reduce complexity (Fiske, 1984) and influence a person's perceptions, decisions, and behavior. Expected events are perceived more strongly, while unexpected events tend to go unnoticed (Good & Nichols, 2001; Weinstein, 2018). Gender bias in expectations for higher digital competence for boys and lower digital competence for girls might lead a teacher to interpret a delayed response to a question related to digital technology differently: the teacher might interpret the girl's delay in responding as a sign of a lack of knowledge, whereas the boy's delay might be seen as an indication that the student is formulating a thoughtful answer. Subsequently, differences in interactions based on gender-biased expectations lead to differences in learning opportunities and thus to inequalities in education (Wang et al., 2018). In digital education, the risk of biased interactions between boys and girls is high: the accuracy of teachers' judgments of technical skills is low and shows a gender bias; teachers had lower expectations for girls. In addition, teachers expressed underestimation more often than overestimation for both boys and girls (Wammes et al., 2022). This underestimation might be explained by the fact that low teacher competence in digital education is associated with low and biased expectations of students' digital competence (Gray & Leith, 2004).

Teachers' guidance in play integrates children's contributions, responds to these contributions, or extends the scope of these contributions in the moment of the teacher playing with the children (Hollenstein & Vogt, 2024; Zosh et al., 2018). Guided pretend play is highly complex. Teachers encounter high complexity of demands during guided pretend play, as they receive a lot of information at the same time and have to process it quickly in the flow of the play interaction. Consequently, the risk of (biased) expectation play behavior during guidance is high. It can be assumed that expectations guide and regulate teachers' perceptions, decisions, and behaviors during guided pretend play. It follows that it is important for teachers to learn to have high and unbiased expectations as part of their training. Intervention studies have shown that awareness and reflection on one's own practice are prerequisites for changing biased expectations into unbiased expectations (de Boer et al., 2018).

1.4. Aims

Expectation research in classrooms underscores the importance of teacher expectations for student achievement (Wang et al., 2018). Teacher expectation behavior is an important factor and is relevant for providing equitable learning opportunities to all children (Hollenstein, 2021; Rubie-Davies et al., 2015). Inequality in digital education can lead to long-term disadvantages (El-Hamamsy et al., 2023). In addition, the risk of underestimation and biased expectations (lower expectations for girls) regarding digital technology has been identified (Wammes et al., 2022). Therefore, children need gender-unbiased guidance to explore digital technology and digital transformation and to experience themselves as active agents. Within pretend play on digital transformation, children take on different roles, free from traditional gender stereotypes. The teacher's unbiased behavior during guided play is therefore central to children's equal learning opportunities. The aim of this paper is to investigate teachers' play behavior and the differences in this behavior with boys and girls during guided pretend play in the context of digital education. The research questions are as follows: (1) whether high-expectation behavior is present in the behavior of kindergarten teachers during guided pretend play, and (2) whether the teachers' expectation play behavior reveals different expectations for boys and girls.

2. Materials and Methods

This study followed a mixed-method design within the framework of a "qualitative-dominated cross-over study" (Kansteiner & König, 2020; Onwuegbuzie & Hitchcock, 2015). Qualitative analysis allowed for observing teachers' play behavior when guiding play, whereas quantitative analysis was used to determine whether the expectationplay behavior differed between boys and girls.

2.1. Sample and Study Design

As part of the exploratory intervention study "We play the future" (Vogt & Hollenstein, 2021), sequences of guided pretend play were examined to analyze teachers' play behavior during guided pretend play in the context of digital education. Additionally, this study aimed to explore whether teachers' expectations play behavior differed between boys and girls.

The intervention study was conducted in 15 kindergartens across German-speaking Switzerland. Teachers were recruited through advertisements in professional journals and on online platforms. The intervention comprised a professional development session and the implementation of activities designed to foster pretend play centered on digital transformation. Kindergarten teachers participated in a half-day professional development program facilitated by the research team. The professional development included an introduction to digital transformation and guided play activities, as well as a short input on the importance of gender equity in digital education. The participating kindergartens were equipped with a range of materials for pretend play, such as wooden tablets with replaceable cardboard screens, as well as detailed instructions on how to introduce and implement these activities in their kindergarten (Vogt et al., 2020). The provided materials consisted exclusively of nonfunctional devices to encourage imaginative play. Subsequently, they introduced at least three of the eight pretend play activities provided by the research team in their kindergarten over a period of 3.5 months.

The teachers initiated these activities on digital transformation by engaging in pretend play with the children and demonstrating digital (transformation) processes. Following this, the children were given the opportunity to engage in pretend play independently, with teachers occasionally joining to encourage ideas and collaboratively support reasoning.

The participating children were aged between 4 and 6 years. No data were collected on the children's characteristics, such as their socioeconomic background or prior knowledge.

2.2. Data Collection and Analysis

Given the exploratory nature of the research questions, a qualitative design was developed for this study, primarily relying on video observation. The analyses of the video observations were enriched with quantitative analyses to compare the differences between teachers' behaviors toward boys and girls.

The database contains video sequences. Children's play was video recorded on two occasions over a period of 3.5 months. Two video cameras on tripods and additional small microphones positioned in the play area were used to capture the play sessions, resulting in 45 h of video material. Teachers frequently joined the pretend play. Written informed consent was obtained from the parents and teachers for the video recordings. On recording days, the children were free to choose whether they wanted to participate in the video recordings or engage in a different play area.

To examine teachers' play expectation behaviors, sequences were selected with an explicit focus on the digital transformation. The second criterion was the presence of a teacher and a group of children with at least one boy and one girl. This resulted in selected sequences of 2 h and 24 min for an in-depth analysis. The video data were primarily analyzed using qualitative content analysis (Mayring, 2022) and coded using MAXQDA 2020. A category system, grounded in the theoretical concepts of high-expectation behavior in classrooms (Rubie-Davies et al., 2015; see Section 1.2 "Teacher expectations and teachers' high-expectation behavior"), was adapted to the pretend play context (where necessary) prior to the analysis of the video data (see Table 1).

Table 1. Extract from category system (deductive developed categories of high vs. low teacher expectation behavior).

Dimensions of High-Expectation Behavior in School (Rubie-Davies et al., 2015)	Category of Expectation Play Behavior During Guided Pretend Play in Kindergarten	Subcategory for the Data Analysis	Example from the Current Data
Focusing feedback on content rather than children's behavior	Feedback	Content *	During a problem-solving process: the educator says to the child: "That is fast, you can take even longer. But it's fine".
		Behavior	"Stop it, not that quick". Teacher to a child running to the IT centre.
Providing cognitive activating input (e.g., asking open-ended questions),	Question (Input)	Open *	"What should we ask the smart fridge?"
		Closed	"Do you want to put eggs in the dough?"
Giving students opportunities to respond (output)	Support (Output)	Requested *	Child: "Can you help me?", Educator: "Take the tablet and put it in front of you".
		Not requested	Educator to the child (without request): "You need to call the technician".
Creating a warm learning environment/classroom climate	Not included, because all recorded play sequences displayed joyful engagement and a warm climate		

* Subcategories mediate high-expectation play behavior (Rubie-Davies et al., 2015).

Each interaction between the teacher and one or several children in a mixed-gender group was coded in detail. The categories were based on three dimensions suggested by Rubie-Davies et al. (2015) as categories of high expectations in schools and were adapted for guided play: 'feedback', 'questions', and 'support' (see Table 1). The dimension 'warm classroom climate', which was suggested for schools (Rubie-Davies et al., 2015), was not included as a category for guided play, because all recorded play sequences displayed joyful engagement and a warm climate. Following Rubie-Davies et al. (2015), 'feedback on content', 'open questions', and 'requested support' mediate high expectations, whereas 'feedback on behavior', 'closed questions', and 'support provided when not requested' indicate low expectations.

'Feedback on content' is conceptualized as feedback that addresses academic learning processes (Rubie-Davies, 2014). For the pretend play context, feedback on content was coded under the following criteria: evaluation, extension, reinforcement, or categorization of a comment; addition to the content; thinking aloud to model thought processes; or identification of contradictions. 'Feedback on behavior' was coded when the teacher provided feedback on how the child should behave (e.g., not running aroundin kindergarten). The code 'support not requested' was used to categorize situations in which the teacher provided concrete instructions for the child's playing, yet the child did not indicate a need for such instructions. If the child indicated a need for such instructions (e.g., looking at the teacher and stopping playing, not answering a question, or asking the teacher for help), it was categorized as 'support requested.'

To ensure inter-rater reliability, approximately 20% of the video material was randomly selected and coded independently by two researchers. Inter-coder reliability was very good, with a kappa of $\kappa = 0.84$ (Brennan & Prediger, 1981). From the 2 h and 24 min of analyzed video material, a total of $N = 1231$ incidents were identified that indicated high or low teacher expectation play behavior.

Quantitative analyses were conducted to compare teachers' play behavior (high vs. low-expectation play behavior) between boys and girls. Using chi-square tests, the frequencies of high vs. low teachers' expectation of play behavior toward boys and girls were tested for significance.

In addition to the deductively developed categories and the quantitative analyses of differences between the interactions with boys compared to girls, we analyzed in an explorative and inductive approach what kind of behavior during guided pretend play reveals a teacher's high-expectation behavior. The excerpts presented below are based on a typical case sample to illustrate how teacher expectations are revealed in the teacher's guidance during pretend play.

3. Results

The presentation of the results follows the research questions: (1) whether high-expectation behavior was found in the behavior of kindergarten teachers during guided pretend play, and (2) whether the teacher's expectation play behavior revealed different expectations for boys and girls.

In order to contextualize the analysis, an overall analysis of interactions between teachers and children is provided: In total, most of the two-and-a-half-hour (144.50 min) interactions occurred when boys and girls were present (104.73 min). There was no significant difference between the total duration of interaction (when girls and boys played together with the teacher) with girls (47.33 min) and boys (44.28 min). The interaction with boys and girls at the same time amounted to 13.13 min.

3.1. Teacher Expectation Play Behavior

Overall, 1231 incidents of teachers' expectation behavior were allocated in the video material. With regard to research question one, the results show that high-0expectation play behavior ($N_{CodeHighExpect} = 397$) was coded during guided pretend play sequences, but less frequently compared to low-expectation play behavior ($N_{CodeLowExpect} = 834$; $\chi^2 = 155$; $p < 0.001$). The frequencies of the subcodes are shown in Table 2. In terms of high-expectation play behavior, 'feedback on content' and 'open-ended questions' frequently occurred in teacher–child interactions during guided pretend play. 'Support on request' was less frequent, with only eight incidents. Low-expectation play behavior, such as 'closed questions' and 'unrequested support', occurred more frequently than 'feedback on behavior' (five incidents).

Table 2. Frequency of high- and low-expectation play behavior incidents.

Category	Subcategory	Total		Girls		Boys	
		Absolute	**Percentage**	**Absolute**	**Percentage**	**Absolute**	**Percentage**
Feedback	Content *	234	19.00	134	17.40	100	21.69
	Behavior	5	0.41	3	0.39	2	0.43
Question (Input)	Open *	155	12.59	97	12.60	58	12.58
	closed	412	33.47	270	35.06	142	30.80
Support (Output)	Requested *	8	0.65	7	0.91	1	0.22
	Not requested	417	33.87	259	33.64	158	34.27
Total		1231	100.00	770	100.00	461	100.00
Total high-expectation play behavior		397	32.25	238	30.91	159	34.49
Total low-expectation play behavior		834	67.75	532	69.09	302	65.51

* Subcategories mediating high-expectation play behavior (Rubie-Davies et al., 2015).

3.2. Difference in High vs. Low Teacher Expectations Between Boys and Girls

To answer research question 2, the difference in incidents of high vs. low teacher expectation play behavior between boys and girls was tested for significance using chi-square tests. Overall, more incidents of teacher expectation play behavior occurred in interactions with girls than with boys ($n_{girls} = 770$; $n_{boys} = 461$; $\chi^2 = 77.60$; $p < 0.001$), although the duration of the interaction (girls: 47.33 min; boys: 44.28 min) was not significantly different (see above). Table 2 shows that all subcategories of teacher play behavior occurred more frequently (in absolute terms) with girls than with boys. Comparing the percentage distribution of the subcategories, there were no significant differences, except for the subcategory 'feedback on content'. Here, in the percentage of total incidents per gender group ($\text{percentage}_{girls} = 17.40$; $\text{percentage}_{boys} = 21.69$), girls had less 'feedback on content' compared to boys ($\chi^2 = 3.01$; $p = 0.09$).

3.3. Explorative, Qualitative Analyses of High and Low Teacher Expectation Play Behavior

The following excerpts are presented as examples of typical incidents of high- or low-expectation play behavior situations. The excerpts provide deeper insight into play sequences and how teachers' expectations of play behaviors during guidance are fluid. The aim was to better understand high-expectation play behavior during guidance (research question 1) and different play behaviors toward boys and girls (research question 2).

Excerpt 1:

A girl sits at the IT center switchboard. A phone and a tablet are lying on the table in front of the girl. The screen of the tablet, consisting of a laminated sheet of paper, has become detached from the casing, a wooden clipboard. The girl dials a number on the phone, makes eye contact with the teacher, holds the damaged device in the teacher's field of vision, and verbally requests assistance (8:40). The teacher arrives at the table and asks: "Did you call me?" (8:46). The child immediately hands the damaged device to the teacher. However, the teacher encourages the girl tackle the repair: "Are you sure you don't want to do it on your own?" (8:57). Only after the girl answers "yes" *the teacher asks her: "Would you like me to show you?" With the device in hand, the teacher takes a seat next to the girl. Step by step, the teacher attaches the sheet to the clipboard and verbally accompanies her actions (9:10). The girl observes the teacher's acting. After the device is repaired, the teacher says: "Next time you can do it on your own" (9:12). Later on, the girl request support while pretending to be an IT expert (22:30; 32:30), but the teacher answer "You work in the IT Center, you are the expert".*

In excerpt 1, the initiative for seeking the teacher's support comes from the girl (8:40). Following this, the teacher makes sure that the girl really needs help by asking her a closed question (8:46), which can be interpreted as ensuring that support is requested. The teacher reiterates the expectation that the girl should do the task (8:57). Then the teacher helps the girl (8:57–9:10) by modeling how she solves the practical task. After completion, she expresses the expectation that next time the girl can do it on her own (9:12). During the interaction, the teacher repeatedly emphasizes her confidence in the girl's ability to solve the problem without the teacher's help next time. The teacher encourages the girl to act independently, showing high expectations.

Excerpt 2:

The teacher assigns roles for a play involving online shopping and an IT center. There are two boys and two girls who want to play with the teacher: "Ok, we will play something new with a mother and children". A girl wants to be a child (27:58). A boy is already sitting in the IT center as an IT expert. A boy and a girl stay next to the teacher and do not say which role they want to play. The teacher assigns the roles and says to the boy, "You will work in the IT center and [girl's name], you are my second child (28:11). Subsequently, two boys are IT experts in the IT center. The teacher plays the role of the mother in the home corner. The girl who says at the beginning that she wants to be a daughter begins the play, "Mommy, I have no dress. All the dresses are too small" (28:46). They want to order new clothes. This involves a tablet and a suit that can automatically measure the body size to order the correct size of clothes. The teacher pretends that the tablet is broken. (30:10) The teacher takes the tablet to the IT center and says to the boys in the IT center: "Our tablet is broken. Is it possible to fix it here?" The boys nod and say: "Yes" (30:45). One boy picks up the tablet. The teacher asks if she has to wait in the IT center or if it is possible to pick up the tablet later (30:55). The boys fix the tablet (by talking together and typing on their laptop). After this problem-solving process, the teacher picks the tablet up and pays by card (31:45). Afterward, the teacher sits between her daughters and holds the tablet in her hand. One girl is wearing the suit that can automatically measure the required clothing size. (32:59) The teacher opens the interaction by asking this girl 1: "What are we going to order for you?" (33:02). Without giving much space for an answer, the teacher suggests: "We could order a black dress to match your sister's" (33:09). Girl 2 makes a different color suggestion, which is not taken up by the teacher. The teacher pretends to take note on the tablet and says: "A black one. I'll write it down" (33:15). The teacher then announces the next step: "And now the size," while moving the tablet up and down in front of girl 1 to scan the clothing size (33:21). Then the teacher says: "Done. Black dress. You can take the suit off again" (33:29). Girl 2 remarks that she has already grown again, whereupon the teacher says: "We'll wait for your sister's order first" (33:40). A third girl in the role of the mail carrier rings the doorbell. The teacher gives instructions to girl 2: "Open the door, [Name of girl]. Will you go" (33:49). The mail carrier hands the parcel and leaves. The teacher calls out "Goodbye" and instructs the girls: "Say goodbye to the mail carrier" (34:00). The girls say goodbye.

In excerpt 2, the play is mainly directed by the teacher. The teacher assigns roles. At this moment, the girls experience for the first time that the teacher does not see them as capable of acting independently, as she assigns the technical roles to the two boys. The girls are daughters and do not use the tablet at all (28:11). The teacher is responsible for all operations involving the tablet. In contrast, the two boys are IT experts. The teacher hands them the broken tablet and asks them a closed question about whether they can help her (30:45). The boys confirm that they can fix the tablet. The teacher asks whether she can leave the tablet and pick it up later; she fades out and leaves the boys to fix the tablet on their own (31:45). The boys are given the opportunity to experience themselves as being able to act independently and confidently with digital devices. They solve the problem together and independently of the teacher. The teacher collects the tablet and continues the order, thus pretending that the tablet was repaired and is working again. This can be seen as positive feedback on the boys' repair work. The teacher orders new clothes with the girls. As the teacher does not pause after her open question about the order (33:02), she does not give the girls enough time to respond. By not accepting the girl's color suggestion (33:15), the teacher shows little consideration for the girls' agency, as their choice is not integrated into the play. The children receive unrequested support in the form of several successive instructions (33:29; 33:49; 34:00). The girls are less active than the boys and have fewer opportunities to contribute to the play. Throughout the sequence of mother and children, the teacher is the only one handling the wooden tablet, thus demonstrating low expectations of the girls' ability to use digital technology.

Excerpt 3:

Two children sit at an IT center desk. Both have a computer in front of them. The boy sits facing the room, the girl sits at a 90-degree angle to the side. The teacher sits behind both children and leans back. A boy comes to the front desk and says as a customer: "My computer is broken" (4:06). While the customer explains the damage to the laptop, the boy at the front desk takes a tablet into his hands and asks the costumer: "What is broken?" The teacher reaches from behind to the boy's tablet and fixes the attachment of the sheet to the wooden tablet without saying anything (4:38). While the customer talks about the language settings of the broken laptop, the teacher briefly turns to the girl at the side desk: "You can log in" (5:00). The girl types on the keyboard. The teacher asks the customer what brand the laptop is. The customer shows his laptop to the teacher, whereupon the teacher says to the girl: "You have to type this in" (5:37). The girl types on the keyboard. The customer states that it is not the right language on the laptop (5:52). The teacher points to the girl's screen and says to the girl: "Oh, look, there's the error message. Could you try to reprogram that?" (6:00). Again, the girl taps the keys.

In excerpt 3, the teacher is leaning back, thus allowing the boy's agency as an IT expert dealing with a customer. The teacher fixes a clipboard without being asked for help (4:38), and at the same time, lets the conversation between the two boys continue without her interference. The teacher probably tries to integrate the girl into the play. She gives unrequested instructions (5:00), keeping the girl busy pretending to type on the keyboard without letting her actively participate in the actual problem-solving process. Her perspective or ideas for solving the broken laptop are not asked for or supported. At the end, the teacher asks the girl for help with the error message and asks if she can reprogram it (6:00). Here, the teacher reveals that she sees the girl as capable of doing so, but she asks her if she can do this with a closed question and not with an open question such as "How you would reprogram that?". The girls' actions during the play are without a verbal contribution, only typing on the keyboard on request.

Excerpt 4:

In the home corner, internet of things has been installed, with kitchen utensils being smart technology. Two girls play the family, they call the IT center. A boy is coming to the family home in the role of the IT expert in order to repair the smart devices. He phones the teacher in her role as a fellow IT expert at the IT center and explains to her that he will repair the fridge first. The teacher confirms: "Yes, this is fine. This is the most important device because it is warm outside". A girl is near the teacher in the IT center and also plays an IT expert (37:55). The teacher, who is sitting in front of the computer, asks the girl if she wants to go back to the seat in front of the computer (37:57). The boy says to the girls playing the family that they should turn the fridge on and look if the fridge *will get cold again (38:01). The girl in the IT center sits down in front of the computer, looks at the screen, and says that the fridge is installed correctly (38:15). The boy playing the IT expert checking the device in the home corner mentions on the phone to the teacher that a sensor is missing. The teacher responds that she will hand the phone to the girl, because the girl is sitting in front of the computer (38:18). The teacher pretends to not know: "I do not know yet, I do not have an overview. [Girl's name], maybe you can help [boy's name] in the home corner? Maybe you can have a look on the computer what you see". (38:39). The girl takes the phone, "OK". The teacher says to the girl: "I think we do not have any sensors at the moment, but we can order some" (38:43). The girl answers: "Yes". The teacher adds: "Tell [boy's name] that we can organize a new sensor, but it takes a little bit of time" (38:48). The girl informs the boy on the phone and says good-bye to him (39:07).*

In excerpt 4, the teacher, girl, and boy are IT experts (37:55). The teacher offers the girl a seat in front of the computer (37:57), passes the phone to her (38:18), and lets her handle the computer (38:39), a behavior that reveals the teacher's high expectations of ensuring the girl's agency. Then, the teacher stays in the computer center and makes suggestions, thus supporting the girl without request (38:39; 38:48) and without giving her time to react on her own. In contrast, the teacher did not go to the home corner and did not offer unrequested support to the boy. Both the girl and the boy play active roles as IT experts. However, the boy is able to act autonomously throughout the sequence, while the girl is not given the opportunity to act autonomously. Over the course of time during this sequence, the girl changes in agency from that of an active participant with verbal contributions ("The fridge is installed correctly", 38:15) to that of a passive participant who only reacts to the teacher's request.

In summary, the four excerpts show that teacher behavior revealing high expectations during guided pretend play in kindergarten may include the following:

- giving children enough time to respond,
- allowing children to generate their own ideas, e.g., how to solve a digital problem,
- asking children about their ideas,
- fading out or staying in a less active role as a co-player, and
- assigning roles to ensure that both girls and boys play active roles (e.g., as IT experts).

Such teacher behavior indicates that a teacher's high-expectation play behavior can be characterized as fostering children's agency in joint play. In the short sequences there are indications that children's agency diminishes when the teacher does not give them enough time to respond (excerpt 2 or 4) or does not ask for their ideas (excerpt 1 or 3).

4. Discussion

This paper focuses on teachers' high-expectation play behavior during guided pretend play sequences on digital transformation in kindergarten. Guided pretend play is promising for developing agency in a digitalized society. At the same time, it is challenging to ensure such opportunities for agency for all children. During guidance, the risk of biased expectations coming to the fore is high.

4.1. Core Findings of Teachers' Expectation Play Behavior

The first research question focuses on the possibility of observing teachers' high-expectation play behavior in a similar way as high-expectation behavior has been observed in classrooms by Rubie-Davies (2007). The results show that it is possible to reliably observe high-expectation teacher play behavior. Nevertheless, low-expectation behavior is more common than high-expectation play behavior. About two-thirds of the incidents show low-expectation play behavior. Low-expectation behavior, such as asking closed questions and providing unrequested support, is often observed during guided pretend play sequences. These results are in line with other research findings that teachers' judgments of the technical skills of children are low (Wammes et al., 2022). In conclusion, teachers do not have high expectations of children acting independently and autonomously in guided pretend play situations on digital transformation topics.

The second research question focuses on the differences in teachers' high-expectation play behavior when teacher–boy and teacher–girl interactions are compared. Gender bias and underestimation have been found in other empirical studies (Gentrup & Rjosk, 2018; Wammes et al., 2022; Wang et al., 2018). Gender bias may be based on the stereotype (Chick et al., 2002) that boys are better at understanding digital technology. Low teacher competence in digital education is also associated with low and biased expectations of students' digital competence (Gray & Leith, 2004). The results of the chi-squared tests show that there are significant differences between girls and boys in the overall frequency of interaction, including expectations. In all, 62.55% (n = 770 of N = 1231 incidents) of all expectation play behavior incidents occur with girls. This means that girls receive more attention from the teacher overall. In terms of percentage distribution, boys and girls receive similar amounts of high- and low-expectation play behavior (high expectations about one-third, low expectations about two-thirds). The percentage distribution of the subcategories also shows no significant differences between boys and girls, except for the subcategory 'feedback on content'. As a percentage of total incidents per gender group, girls tend to receive less feedback on content compared to boys.

Due to the higher number of interactions with girls, the teacher shows both high and low expectations of girls more often than of boys. Rubie-Davies (2007) stated that a high-expectation teacher treats all students equally. Accordingly, boys and girls should receive the same number of interactions regarding their expectations. While the total duration of interactions in this study was equally distributed between boys and girls (girls: 47.33 min; boys: 44.28 min), the incidents of high- and low-expectation behavior were not equally distributed (girls: 770 incidents; boys: 461 incidents). Girls receive more feedback, more questions, and more support than boys. It remains questionable whether girls perceive themselves as capable of acting independently, as they receive more expectation behavior. The teachers' behavior of expressing expectations more often with girls than with boys may affect girls' experience of agency, and they may not develop confidence as active participants in a digitalized society.

The in-depth qualitative analysis presented above with four excerpts highlights five important teacher behaviors that may reveal high expectations during guided pretend play: (1) giving children enough time to respond, (2) allowing children to generate their own ideas (e.g., on how to solve a digital problem), (3) asking children about their ideas, (4) fading out or staying in a less active role as a co-player, and (5) assigning roles to ensure that both girls and boys play active roles (e.g., IT experts). All these behaviors may reveal high expectations of the teachers that the children are capable of being active participants in a digitalized society. In the four excerpts, as examples, the opposite of such behavior was mostly found toward girls: the teacher does not give the girls enough time to respond (excerpt 2), does not allow girls to generate their own ideas, e.g., how to solve a digital problem (excerpt 3), does not ask girls about their ideas (excerpt 1), does not fade out or does not stay in a less active role as a co-player (excerpt 4), and does not assign roles to make sure that both girls and boys play the active roles (excerpt 2). Moffatt et al. (2009) identified parental behaviors that encourage a child to be active in mathematical content and showed significant gender differences (girls experienced fewer behaviors that encouraged them to be active). If the play behaviors identified in this paper are indeed indicative of high-expectation play behaviors, further research is needed to examine teacher expectations and the differences in play behaviors between high- and low-expectation teachers.

The results underline how challenging unbiased high-expectation play behavior is and what kind of behavior reveals such high expectations. The question then arises as to whether it is possible to learn high-expectation play behavior through guided pretend play. Looking at the classroom and teacher–student interactions, high-expectation behaviors in the classroom can be developed through workshops that combine theory on the importance of high expectations, examples of high-expectation play behavior, and opportunities for teachers to exchange experiences regarding classroom interactions. Additionally, analyzing their own videotaped teaching sequences can help teachers to improve their practices (Rubie-Davies et al., 2015). Teacher training courses should address the importance of unbiased high expectations. During internships, pre-service teachers might reflect on their expectation behavior and identify possible biases. Professional development on teachers' expectations in their interactions with children should include reflection and awareness of one's own (biased) expectations and help develop unbiased high expectations for all children.

4.2. Potential of High-Expectation Play Behavior for Children's Agency

The results strengthen the assumption that guided pretend play for digital transformation encourages children's agency in a digitalized society. In guided pretend play, children are given the opportunity to imagine being in control of digital technology (Arnott et al., 2020; Bird, 2020; Vogt & Hollenstein, 2021), act independently, and make choices. For both girls and boys, it is crucial to develop an early interest in professions within the field of information technology (Turja et al., 2009). Guided pretend play offers a valuable opportunity to do so and to imagine future agency.

However, the results also show that guidance based on biased expectations can hinder children's agency in digital education, as their agency can be strengthened or weakened (Jerome & Starkey, 2022). The risk of underestimation and biased expectations toward children's capability to act independently and autonomously in pretend play settings on digital transformation is high. As inequality in digital education can lead to long-term disadvantages (El-Hamamsy et al., 2023), children need gender-unbiased guidance to explore the processes of digital transformation and experience agency in digital education early on.

4.3. Strengths and Limitations

This paper provides the first insight into how teacher expectations can be revealed during guided pretend play in kindergarten. It underscores the importance of unbiased guidance to provide all children with the opportunity to experience agency in a digitalized society. The study indicates that teacher expectations are mediated in guided play, taking similar forms as in primary and secondary school settings, but also involving other aspects. Feedback on behavior, which is considered low-expectation behavior, might not occur as frequently in pretend play in kindergarten as it does in school, as children enjoy playing. In addition, due to the pretend play context, requests for support are less necessary because there is no correct or incorrect solution in pretend play. A strength of this study is that it applies high-expectations research findings from the school setting to the context of guided pretend play in kindergarten. The inductively developed categories provide an initial indication of what teacher play behavior may reveal high expectations.

As a limitation, it was not possible to control for children's competence level or teachers' overall expectations of individual achievement for children. In addition, information on contextual variables such as teachers' previous experience with digital education, class size, or institutional policies on digital learning is missing in this study. To better understand teacher expectation behavior during guidance, teacher expectations should be assessed quantitatively to compare teachers who overall hold high versus low expectations regarding their behavior during guidance (following Rubie-Davies, 2007, for primary and secondary school teachers and their classroom behaviors). Additionally, contextual variables should be taken into account.

When interpreting the findings, it should be kept in mind that the teachers' professional development was short, only half a day, and covered the topics of digital transformation, guided pretend play activities, and gender-sensitive guidance. Such short professional development is limited in its impact on teachers' expectations of play behavior (Rubie-Davies et al., 2015). In order to address possibly biased expectation play behavior, more intensive professional development may be needed.

Furthermore, the analyses do not account for the consistency of teachers' interactions with each child. Teacher expectations are understood to influence student perceptions, self-concept, and achievement when teachers reveal their expectations through consistently recurring behaviors with children (Lorenz, 2018). In order to assess the consistency, a longitudinal study would be needed. A longitudinal study allows for the analysis over time of how teachers' expectations affect children's agency in the long term.

5. Conclusions

In conclusion, the analysis presented here suggests that gender equity for agency in learning about digital transformation in early childhood education requires more attention for the following reasons: First, teachers show high-expectation play behavior with both boys and girls, but low-expectation play behavior is much more prevalent than high-expectation play behavior. Second, teachers show more incidents of expectation play behavior with girls compared to boys, although the duration in minutes of interaction with the teacher during play does not differ significantly between boys and girls. Third, expectation behaviors in the classroom do not transfer one-to-one to guided pretend play situations in kindergarten. Fourth, the results strengthen the assumption that unbiased guidance by teachers during pretend play in kindergarten has the potential to ensure agency for all children in a digitalized society.

Further research is needed to examine teachers' high expectations during their guidance and to analyze the possibility of learning high-expectation play behavior during guided pretend play on digital transformation in kindergartens. More empirically based findings are needed on kindergarten teachers' expectation play behavior during guidance and its relevance for equitable learning opportunities and equity in the development of agency in a digitalized society.

The research reveals the fluidity of expectation play behavior during guided pretend play: guided pretend play has the potential not only to reproduce gender stereotypes, but also to overcome them and strengthen children's agency in digital education.

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they wanted to participate in the video recordings or devote themselves to another play area. There was no ethics committee established at St. Gallen University of Teacher Education; therefore, no ethical approval could be obtained. The St. Gallen University of Teacher Education upholds the regulations of the Swiss Academies, which were followed throughout the study.

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Article

Investigating AI Chatbots' Role in Online Learning and Digital Agency Development

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Abstract: The integration of artificial intelligence (AI) chatbots in online learning environments has transformed the way students engage with educational content, offering personalised learning experiences, instant feedback, and scalable support. This study investigates the role of AI-driven chatbots in the Pedagogical Information and Communication Technology (ICTPED) Massive Open Online Course (MOOC), a professional development course aimed at enhancing teachers' Professional Digital Competence (PDC). The study pursues two connected aims: (1) to examine how chatbots support content comprehension, self-regulated learning, and engagement among pre- and in-service teachers, and (2) to explore, through a cultural-historical perspective, how chatbot use contributes to the development of students' digital agency. Based on data from 46 students, collected through structured questionnaires and follow-up interviews, the findings show that chatbots functioned as interactive learning partners, helping students clarify complex concepts, generate learning resources, and engage in reflection—thereby supporting their PDC. At the same time, chatbot interactions mediated learners' development of digital agency, enabling them to critically interact with digital tools and navigate online learning environments effectively. However, challenges such as over-reliance on AI-generated responses, inclusivity issues, and concerns regarding content accuracy were also identified. The results underscore the need for improved chatbot design, pedagogical scaffolding, and ethical considerations in AI-assisted learning. Future research should explore the long-term impact of chatbots on students' learning and the implications of AI-driven tools for digital agency development in online education.

Keywords: AI chatbots; online learning; digital agency; professional digital competence; MOOCs; teacher education; cultural-historical perspective

1. Introduction

The integration of chatbots into online learning represents a promising advancement in digital education, offering benefits such as personalised learning, immediate feedback, and enhanced engagement (Hew et al., 2023; Jeon et al., 2023). However, challenges related to chatbot comprehension, student over-reliance, and inclusivity should be addressed to reveal their pedagogical potential (Chang et al., 2023; Lee et al., 2020). Crucially, research is needed to examine how both students and educators, particularly those engaged in professional development, utilise chatbots in asynchronous online learning environments

(Du et al., 2021; Han & Lee, 2022). A more comprehensive understanding of chatbot interactions in these contexts will inform the development of more effective and equitable online educational environments (Engeness & Nohr, 2020; Siddiq et al., 2024).

By leveraging artificial intelligence (AI) and natural language processing (NLP), chatbots provide scalable support for students, addressing challenges such as limited instructor availability in flexible learning environments (Hew et al., 2023; Hwang & Chang, 2023). The ability of chatbots to facilitate student engagement, assist with content navigation, and promote self-directed learning has led to their widespread adoption in various educational contexts, including Massive Open Online Courses (MOOCs) and teacher professional development programmes (Du et al., 2021; Han & Lee, 2022).

In MOOCs, where large numbers of participants require scalable and adaptive support, chatbots have proven particularly beneficial. They serve as interactive learning assistants by responding to student queries, guiding learners through course content, and providing timely feedback (Jeon et al., 2023). Research highlights the effectiveness of chatbots in STEM education, where they support problem-solving and conceptual understanding through step-by-step guidance (Atmosukarto et al., 2021; Cheng et al., 2024). Similarly, in language learning, chatbots act as conversational partners, aiding in vocabulary acquisition, fluency development, and self-regulated learning (Sáiz-Manzanares et al., 2023). Despite these advantages, concerns remain about chatbot reliability, students' over-reliance on AI-generated responses, and the inclusivity of chatbot-based learning experiences (Chang et al., 2023; Lee et al., 2020).

A growing body of research suggests that chatbots not only enhance student engagement and content mastery but also play a role in fostering digital agency—the ability of learners to critically interact with digital tools, adapt their learning strategies, and engage in collaborative knowledge construction (Engeness & Nohr, 2020; Siddiq et al., 2024). From a cultural-historical perspective, digital agency emerges through the mediation of technological tools within socio-cultural learning environments (Engeness, 2020; Engeström, 1999). In this context, chatbots act as cognitive mediators, enabling learners to navigate digital learning spaces, develop metacognitive skills, and exercise autonomy in their learning processes. However, to maximise the pedagogical potential of chatbots, it is essential to understand how they shape students' digital agency and learning experiences.

This study examines the role of AI chatbots in the ICTPED MOOC, an online course designed to develop Professional Digital Competence (PDC) among pre- and in-service teachers. As one of Norway's longest running and most widely attended MOOCs, ICTPED offers a rich context for investigating chatbot integration in professional learning. The study pursues two interconnected aims: (1) to explore how participants engaged with chatbots to support learning, content comprehension, and self-regulated strategies that contribute to PDC; and (2) to apply a cultural-historical perspective to analyse how chatbot use mediated the development of students' digital agency. These dual aims guide the investigation into participants' motivations, usage patterns, and perceived benefits and limitations of AI-supported learning.

To address these questions, data were collected from 46 participants through a structured questionnaire and follow-up interviews with a subset of learners. The findings contribute to the growing discourse on chatbot use in professional development by exploring the extent to which chatbots influence learning engagement, content understanding, and the development of digital agency. The study also examines the challenges and limitations associated with chatbot-assisted learning, offering insights into how AI-driven educational tools can be improved to better support diverse learner needs. By situating chatbot interactions within a broader theoretical framework of digital agency, this research provides implications for the future design and implementation of AI chatbots in online teacher education and professional development programmes.

2. Students' Use of Chatbots in Online Courses: What Do We Know?

Chatbots have emerged as a significant technological innovation in online learning, offering a range of functionalities designed to support student engagement, self-regulated learning, and academic achievement. Initially developed as simple rule-based systems, contemporary chatbots leverage artificial intelligence (AI) and natural language processing (NLP) to provide personalised and adaptive learning experiences (Hwang & Chang, 2023). The growing interest in chatbots as educational tools is reflected in the increasing number of studies examining their efficacy, particularly since 2017 (Hwang & Chang, 2023).

The literature identifies several categories of chatbots employed in online learning environments. Rule-based chatbots, such as those implemented in Massive Open Online Courses (MOOCs), primarily function as FAQ assistants, addressing student queries related to course logistics and content navigation (Han & Lee, 2022). More advanced AI-powered chatbots, such as those used in self-regulated learning contexts, facilitate goal setting, personalised feedback, and adaptive learning pathways (Du et al., 2021).

Empirical studies have consistently demonstrated the advantages of chatbot-assisted learning. One of the primary benefits is the provision of immediate feedback, which enhances students' engagement, motivation, and self-efficacy (Fidan & Gencel, 2022; Sáiz-Manzanares et al., 2023). Chatbots also contribute to more flexible learning experiences by allowing students to access support outside traditional instructional hours (Deveci Topal et al., 2021). Moreover, they have been found to facilitate social presence in asynchronous learning environments, mitigating the sense of isolation often reported in fully online courses (Hew et al., 2023). Chatbots play a crucial role in self-regulated learning by supporting students in setting and achieving learning goals (Du et al., 2021). Studies indicate that chatbots used for goal setting, such as "Learning Buddy," enhance students' awareness of their learning objectives, leading to increased self-discipline and academic success (Hew et al., 2023). Additionally, chatbots serve as effective tutors in STEM disciplines, providing adaptive problem-solving guidance and improving student comprehension in complex subjects such as chemistry (Atmosukarto et al., 2021) and mathematics (Cheng et al., 2024). Furthermore, chatbots can enhance inclusivity in online education. By offering multilingual capabilities and accessibility features such as text-to-speech conversion, chatbots support diverse learners, including those with disabilities (Chang et al., 2023). Their ability to personalise learning experiences based on students' performance data also allows for differentiated instruction, catering to varying levels of prior knowledge and learning paces (Sáiz-Manzanares et al., 2023). Another key advantage is the ability of chatbots to support peer collaboration and interaction in online courses. Studies show that chatbot-assisted discussions promote critical thinking and knowledge sharing, particularly in collaborative learning environments (Fidan & Gencel, 2022). Additionally, chatbots integrated into flipped learning models facilitate personalised student support and enable real-time clarification of complex concepts (Baskara, 2023).

Despite these benefits, several challenges limit the effectiveness of chatbots in educational settings. One recurring issue is the restricted contextual understanding of chatbots, which often leads to irrelevant or inadequate responses (Lee et al., 2020). Students have reported frustration with chatbots that fail to interpret nuanced queries or provide meaningful explanations beyond predefined responses (Cheng et al., 2024). Moreover, the initial enthusiasm often surrounding chatbot use may diminish over time—a phenomenon known as the novelty effect—resulting in reduced engagement and weakened long-term impact on learning (Wu & Yu, 2024). Another significant concern is the potential over-reliance on chatbots, which may reduce students' critical thinking and problem-solving abilities by encouraging passive learning behaviours (Chang et al., 2023). Overuse of chatbots in problem-solving scenarios has been linked to decreased confidence in independent learning, as students tend to depend on AI-generated responses rather than developing their own reasoning skills (Cheng et al., 2024). While positive outcomes have been reported in STEM and language learning domains, other studies raise questions about the generalisability of these benefits. For example, Wu and Yu (2024) suggest that chatbots may be less effective in supporting interpretive, critical, or affective learning tasks typically found in humanities or higher-order reflective contexts, where AI-generated responses may oversimplify or obscure nuanced understanding. Additionally, while chatbots facilitate self-regulated learning, their effectiveness varies based on students' prior knowledge and educational level, with master's students demonstrating greater benefits compared to undergraduates (Sáiz-Manzanares et al., 2023). While positive outcomes have been reported in STEM and language learning domains, other studies raise questions about the generalisability of these benefits. For example, it has been suggested that chatbots may be less effective in supporting interpretive, critical, or affective learning tasks typically found in humanities or higher-order reflective contexts, where AI-generated responses may oversimplify or obscure nuanced understanding (Wu & Yu, 2024).

Ethical concerns surrounding chatbot implementation in education also pose significant challenges. Issues related to data privacy, algorithmic bias, and potential breaches of academic integrity have been highlighted in the literature (Aguilera-Hermida, 2024). Students' data privacy is a critical concern, particularly when chatbots collect and analyse large amounts of user data to personalise learning experiences (Chang et al., 2023). Moreover, there is an ongoing debate on the extent to which chatbots should be allowed in assessment environments, given their ability to generate responses that may compromise academic integrity (Ilieva et al., 2023). In addition to ethical and usability concerns, studies have highlighted the importance of pedagogical intentionality when integrating chatbots into learning environments. Ilieva et al. (2023) caution against the premature or overly generic use of AI tools in education, noting that without proper alignment to curricular goals, chatbots risk functioning as isolated or even disruptive elements within the learning process. These findings emphasise the need for thoughtful planning to ensure that chatbot interactions contribute meaningfully to educational objectives. Another limitation is chatbot usability across diverse student demographics. Research indicates that non-native English speakers and students from specific geographical regions experience greater difficulties in using chatbots due to language barriers and cultural differences in communication styles (Han & Lee, 2022). Furthermore, some students find chatbot interactions impersonal and prefer human instructor guidance, particularly in disciplines that require subjective interpretation, such as humanities and social sciences (Hwang & Chang, 2023). Scalability remains another challenge, as maintaining chatbot effectiveness in large-scale online courses can be complex. Studies suggest that chatbots require continuous updates and improvements to keep pace with evolving course content and student needs (Deng & Yu, 2023). Without thoughtful integration into the institutional, curricular, and pedagogical structures that shape teaching and learning—alongside collaboration between key stakeholders such as educators, instructional designers, IT developers, and policy-makers—chatbots risk being underutilised or misaligned with educational goals, ultimately reducing their pedagogical impact (Hwang & Chang, 2023). These findings collectively suggest that without thoughtful pedagogical integration and domain-sensitive adaptation, chatbots may not only be underutilised but also risk becoming pedagogically irrelevant or even counterproductive. Their value depends not merely on technical availability, but on the alignment between chatbot functionality, subject-specific learning goals, and instructional design.

Although research on chatbot-assisted learning has expanded considerably, several gaps remain. Most existing studies focus on short-term outcomes, with limited attention given to the long-term impact of chatbots on learning behaviours and academic success (Hwang & Chang, 2023). Additionally, while chatbots have been extensively examined in STEM and language learning contexts, their application in humanities and social sciences remains underexplored (Hwang & Chang, 2023). A particularly underdeveloped area of research concerns the use of chatbots in supporting teachers' professional development within asynchronous online courses. While some studies suggest that chatbots can enhance teacher support and reduce administrative workload (Chiu et al., 2024), their role in fostering professional learning communities and facilitating pedagogical reflection has yet to be systematically investigated. This study addresses this gap by examining how teachers used chatbot in ICTPED MOOC aimed at enhancing teacher digital competence, professional development and agency.

3. Cultural-Historical Perspective on Digital Agency in Online Learning

The cultural-historical theory, originally developed by Vygotsky, provides a theoretical lens through which human cognition, learning, and agency are understood as deeply embedded in social and cultural contexts. From this perspective, agency is not an inherent or static trait of the individual, but rather an emergent and relational phenomenon—shaped through participation in collective activities and mediated by cultural tools and signs (Vygotsky, 1978; Engeström, 1987). Galperin further advanced this perspective by conceptualising learning as the internalisation of actions mediated by material and symbolic resources, positioning learners as active agents who transform both their environment and themselves through goal-directed activity (Engeness, 2021a; Engeness & Gamlem, 2025; Engeström, 1987).

From this perspective, human activity is always socially and historically situated, and the development of agency is contingent on individuals' ability to appropriate and transform available cultural tools. The interplay between human cognition and social context is further reinforced by Galperin's contribution, which conceptualises learning as a dynamic interaction between subject, object, and mediating artefacts (Engeness, 2021a). This systemic approach underscores that agency is not merely about independent action but about the ways individuals participate in collective practices and reshape them through engagement. Furthermore, Galperin's work suggests that cognitive development is deeply tied to material and semiotic tools, which shape learners' abilities to act purposefully within their environments (Engeness, 2021a). These foundational premises reinforce that agency is a process of cultural participation rather than an individual trait, a notion that becomes increasingly significant in the digital age.

In contrast to traditional, transmission-oriented learning environments, socio-cultural learning environments are characterised by collaborative, tool-mediated meaning-making, where knowledge is co-constructed through interaction with both human and non-human mediators. In such contexts, AI chatbots can be understood as cognitive mediators—tools that shape how learners engage with knowledge, reflect on their understanding, and regulate their learning behaviour. These chatbots do not merely deliver information; they structure activity by enabling learners to question, reframe, and evaluate content.

Within the cultural-historical framework, agency is understood as the capacity of individuals to act within and transform their socio-cultural environment. Unlike perspectives that treat agency as an individual attribute, this approach emphasises that agency is relational and context-dependent, emerging through participation in social practices and mediated by cultural tools (Siddiq et al., 2024). Edwards (2015) highlights that agency involves the ability to interpret and respond to social contexts by mobilising resources and engaging in relational practices (Edwards, 2015). This means that agency is not just about independent action but also about forming networks of support and using available tools effectively (Edwards, 2015). Mäkitalo (2016) extends this view by demonstrating how agency emerges through interactional and discursive practices in learning environments, emphasising that it is dynamically constructed rather than a static trait (Mäkitalo, 2016). Engeness (2020) further argues that digital agency is developed through iterative participation in online and digital learning spaces, where learners engage with tools that mediate knowledge acquisition and transformation. In digital settings, agency is not merely about the ability to act but also about learners' capacity to engage in epistemic practices that facilitate meaning-making in technologically mediated environments (Engeness & Nohr, 2020) Digital agency, in this context, extends beyond technical competence to encompass learners' ability to critically engage with digital tools, adapt learning strategies, and participate in collaborative knowledge construction. Within this framework, digital agency is not simply the ability to use technology, but the capacity to strategically appropriate digital tools for epistemic tasks—such as inquiry, reflection, and synthesis—in response to socially situated learning demands (Siddiq et al., 2024; Engeness & Nohr, 2020). This perspective informs our investigation into how participants in the ICTPED MOOC developed digital agency through their interaction with chatbots, and how the design of such tools affords or constrains transformative engagement.

By adopting the cultural-historical perspective, digital agency acquires its transformative nature and is conceptualised as an epistemic and ontological phenomenon where learners actively shape their learning environments through interactions with digital tools (Engeness, 2021b). This transformative process implies that digital agency evolves as learners develop strategies to navigate the demands of online learning. Transformative digital agency is closely linked to learners' ability to engage with and repurpose digital tools for learning and the students' capacity to use digital resources strategically (Engeness, 2020).

However, challenges arise when learners lack the necessary scaffolding to develop digital agency. While some students thrive in digitally mediated environments, others struggle with motivation, digital literacy, and self-regulation (Brevik et al., 2019). Therefore, fostering digital agency requires intentional pedagogical strategies that balance autonomy with structured support. From a cultural-historical perspective, this requires students to appropriate digital tools as mediational artifacts, transforming passive consumption into active knowledge construction (Aagaard & Lund, 2019).

This study employs the cultural-historical perspective to examine how students develop digital agency through their interactions with chatbots in asynchronous online learning environments. By analysing how learners engaged with AI-driven chatbots, the study aims to uncover the socio-cultural dynamics that influence digital agency development. This perspective provides a robust framework for understanding the interplay between AI-technology, social interaction, and learner autonomy in digital education.

4. Method

4.1. Participants and Setting

Data were collected through a questionnaire administered online to 228 pre- and in-service teachers enrolled in the ICTPED MOOC during the spring semester of 2024 (response rate 46 out of 228—approximately 20.2%). In addition, interviews with eight students who had participated in the course were conducted. The study aimed to explore the participants' learning experiences and their use of subject-specific chatbots in the ICTPED MOOC. The questionnaire was designed to capture: (a) general information about the participants, (b) how they used the chatbots in the ICTPED MOOC, and (c) how students' interactions with chatbots contributed to achieving their learning outcomes.

The questionnaire consisted of 35 questions, employing a mix of formats, including a five-point Likert scale for quantitative measures and open-ended questions for qualitative insights. Table 1 presents the number of respondents to the questionnaire, their professional background, and general evaluation of the ICTPED MOOC.

Table 1. The number of respondents to the questionnaire in 2023–24 and their general evaluation of the ICTPED MOOC.

Years	Number of Respondents	Male/Female	Professional Background	General Evaluation of the ICTPED MOOC Mean
2023–2024	46	Male = 5 Female = 41	In-service teachers = 88% Pre-service teachers = 9% Other = 3%	Very little satisfied = 2.2% Little satisfied = 2.2% Somewhat satisfied = 6.5% Strongly satisfied = 65.2% Very strongly satisfied = 26.1%

4.2. ICTPED MOOC

The ICTPED MOOC was first introduced in Norway in 2016 as an xMOOC (Pedagogical Information and Communication Technology Massive Open Online Course) developed by researchers and development specialists at Østfold University College. It is one of Norway's longest running and most popular MOOCs, designed to enhance the Professional Digital Competence (PDC) of pre- and in-service teachers with 1529 participants passed and acquired 15 European Credit Transfer and Accumulation System (ECTS) credits since its launch in 2016 (Engeness & Nohr, 2022). The course integrates pedagogical and technological elements, utilising digital tools to foster active, flexible, and self-regulated learning (Engeness & Nohr, 2020).

The ICTPED MOOC follows an xMOOC structure (Armellini & Padilla Rodriguez, 2016; Fidalgo-Blanco et al., 2016), hosted on the Canvas platform, and is characterised by an institutional focus, reliance on video resources, and automated assessments through quizzes. The course consists of eight modules completed over 20 weeks, each beginning with an introductory section outlining learning goals and expected outcomes. These modules include:

- Textual information presented on webpages
- Embedded research articles
- Videos and audio resources
- Individual tasks and reflection questions
- Multiple-choice quizzes for both formative and summative assessments

Each module starts with an introduction video and textual information, followed by tasks, quizzes, and interactive discussions. Formative assessments are integrated through strategically placed small multiple-choice tests, while summative assessments include larger multiple-choice quizzes at the end of each module (Engeness & Nohr, 2020).

To ensure accessibility, Universal Design principles have been embedded into the ICTPED MOOC. Participants can download course materials in multiple formats, including audio files, podcasts, flat PDF files, and e-books. Each module page also includes embedded audio files to facilitate learning for diverse needs. Additionally, the course design enables flexible engagement, allowing participants to follow different learning pathways based on their preferences.

A key feature of the ICTPED MOOC is its emphasis on participant agency in digital environments. The course structure supports diverse engagement strategies, with some students following a sequential approach (reading text first, watching videos, then engaging with assignments), while others prioritise assignments or collaboration before reviewing instructional content. Analysis of previous course iterations indicates that participants engaged in different entry activities, including: Reading textual information (52.94%); Watching videos (21.57%); Engaging in assignments (9.80%); Listening to audio materials (7.84%) and Other activities (e.g., collaboration and content conversion) (7.86%) (Engeness & Nohr, 2020). This flexible approach allows participants to construct their own learning trajectories, aligning with the course's goal of fostering digital competence and independent learning strategies.

The ICTPED MOOC follows a structured progress plan, detailed in Table 2, which outlines the modules and their corresponding timeline:

Table 2. Progress plan and the modules in the ICTPED MOOC.

Module Number	Module Name	Progress Plan (Week)
0	Pre-course	2
1	ICT and learning	3–4
2	Digital studying techniques	5–6
3	Multimodal texts (examination module)	7–9
4	Cyber ethics	10–11
5	Classroom management in digital learning environments	12–13
6	Assessment for learning	14–15
7	AI in education	16–17
8	Flipped classroom (examination module)	18–21

Upon successful completion of the course (evaluated as pass/fail), participants receive 15 ECTS credits (Engeness & Nohr, 2022).

In the final three modules, students were introduced to chatbots specifically trained on the curriculum for each module. These chatbots were developed using OpenAI's GPT-4 technology and trained using Retrieval-Augmented Generation (RAG) technology to ensure accurate, subject-specific responses. The chatbots were integrated into the course platform and prominently displayed on each module's main page.

To guide students in using the chatbots, three instructional videos were provided, explaining their functionality and purpose. Access to the chatbots required participants to have their own subscription to the paid version of ChatGPT4o.

The ICTPED MOOC has been highly successful, with over 80% of participants completing the course. The integration of structured learning paths, interactive digital tools, and accessibility features has made it a cornerstone of digital competence training for educators in Norway (Engeness & Nohr, 2020).

4.3. Data and Analysis

This study employed a mixed-methods approach (Creswell, 2012) to investigate two central research questions:

1. How did participants engage with AI chatbots to support their learning and the development of Professional Digital Competence (PDC)?
2. How did chatbot use contribute to the development of digital agency, viewed through a cultural-historical perspective?

Data were collected through a structured online questionnaire and semi-structured interviews with participants enrolled in the ICTPED MOOC. A total of 46 participants completed the questionnaire, and eight participants were selected for in-depth follow-up interviews. The questionnaire included a combination of Likert-scale items and open-ended questions, while the interviews explored participants' experiences, motivations, and learning processes related to chatbot use.

4.3.1. Analysis for Research Question 1: Chatbot Use and Professional Digital Competence (PDC)

To explore how chatbots supported participants' learning and contributed to the development of PDC, the questionnaire included three key items:

1. Have you used GPT/chatbots in Modules 6, 7, and 8? (Yes/No)
2. How do you assess the use of GPT/chatbots? (5-point Likert scale: very negative to very positive)
3. How did you use GPT/chatbots in Modules 6, 7, and 8? (Open-ended)

Quantitative data from items 1 and 2 were analysed using descriptive statistics to assess chatbot usage and perceived effectiveness. The results revealed patterns in adoption rates and satisfaction levels among learners.

Thematic analysis (Braun & Clarke, 2014) was applied to responses from item 3 to identify keyways participants used chatbots to support learning. Themes related to clarification of course content, task completion, study resource generation, and assessment preparation were central to understanding how chatbots contributed to PDC.

4.3.2. Analysis for Research Question 2: Chatbot Use and Digital Agency Development

To address the second research question, qualitative data from both the open-ended questionnaire responses and the eight follow-up interviews were analysed through a cultural-historical lens. The interviews focused on the following questions:

4. How did you use the GPT/chatbots?
5. Why did you use the GPT/chatbots?
6. What support did the GPT/chatbots provide to you?

All interviews were transcribed and analysed in NVivo 12 using an inductive coding approach (Patton, 2015). The analysis focused on identifying patterns that reflected learners' development of digital agency—such as metacognitive regulation, critical evaluation of chatbot responses, and strategic use of AI tools in learning.

Emerging themes were interpreted using a cultural-historical framework, with particular attention to how chatbot interactions acted as mediational tools enabling learners to engage in autonomous learning and meaning-making practices.

4.3.3. Integration of Findings

By triangulating the quantitative questionnaire data with the qualitative insights from open-ended responses and interviews, the study offers a comprehensive view of chatbot integration in the ICTPED MOOC. This mixed-methods approach allows for a deeper understanding of how chatbot use supported both the development of Professional Digital Competence and the emergence of digital agency among participants.

5. Findings

5.1. Analysis of the Questionnaire (Research Question 1: Chatbot Use and Professional Digital Competence)

This section presents findings related to Research Question 1: How did participants engage with AI chatbots to support their learning and the development of Professional Digital Competence (PDC)? The analysis draws on three questions from the structured questionnaire, which aimed to explore participants' use of chatbots in Modules 6, 7, and 8 of the ICTPED MOOC.

Q1: Chatbot Usage Frequency

Participants were first asked, "Have you used GPT/chatbots in Modules 6, 7, and 8?" to determine the overall extent of chatbot integration into their learning process.

- 52.2% of participants reported using GPT/chatbots.
- 47.8% stated that they did not engage with chatbots.

These figures indicate that just over half of the participants adopted the chatbot feature. The remaining 47.8% of non-users may reflect a lack of awareness, uncertainty regarding functionality, technical access issues, or a preference for more traditional learning tools. Follow-up interviews confirmed that some learners were unaware of how to access or effectively use the chatbots, while others expressed scepticism about their pedagogical value.

Q2: Perceived Satisfaction with Chatbot Use

The second question asked participants to rate their experience using GPT/chatbots on a five-point Likert scale (1 = very negative; 5 = very positive). The distribution of responses was as follows:

- 0% reported being very little satisfied (1/5)
- 0% reported being little satisfied (2/5)
- 22.2% were somewhat satisfied (3/5)
- 55.6% were strongly satisfied (4/5)
- 22.2% were very strongly satisfied (5/5)

These results reveal a strikingly positive response among users, with 77.8% reporting strong or very strong satisfaction. Importantly, no dissatisfaction was recorded. This high satisfaction rate suggests that those who used the chatbots found them beneficial for supporting content comprehension, navigating the course material, and developing key digital learning strategies.

However, 22.2% of participants who were only somewhat satisfied indicated that the experience, while generally helpful, was not without limitations. Some of these learners cited inconsistent or overly generic responses from the chatbot, while others wanted tighter integration of the chatbot's feedback with course-specific language and tasks. These moderate ratings point to areas for improvement, particularly around alignment between chatbot output and course objectives, subject specificity, and clearer usage guidance.

Q3: How Participants Used Chatbots

In response to the open-ended question, "How did you use GPT/chatbots in Modules 6, 7, and 8?", participants provided a wide range of reflections. A thematic analysis (Braun & Clarke, 2014) revealed five dominant themes, each relating to practices that support the development of Professional Digital Competence (PDC):

1. Clarification and Explanation: Many participants used chatbots to better understand course content by asking, clarifying questions or requesting simplified explanations. The chatbot was described as "a tool for breaking down complex concepts" and "summarising difficult texts". This function supported conceptual mastery and pedagogical understanding—core components of PDC.
2. Assessment Preparation and Study Support: Several participants used the chatbot as a study aid. They asked for example quiz questions, explanations of potential answers, and test preparation summaries. This use case reinforced participants' self-directed learning and goal-setting strategies.

3. Generating Learning Resources: Participants used the chatbot to produce personalised study notes, concept summaries, and learning prompts. This creative use demonstrated higher-order application of digital tools for knowledge organisation and instructional planning, reinforcing PDC dimensions related to content structuring and knowledge dissemination.
4. Exploring Alternative Perspectives: Some respondents reported using the chatbot to request multiple explanations of the same concept or to relate theory to classroom practice. This experimentation supported critical reflection and pedagogical adaptability—key attributes of digitally competent educators.
5. Interactive and Dialogic Engagement: A smaller group of participants described engaging in sustained, back-and-forth conversations with the chatbot, using it as a dialogic partner to test hypotheses or explore what-if scenarios. These learners demonstrated more sophisticated interaction, bordering on exploratory learning and metacognitive reflection. Although this theme overlaps with digital agency, it also signals a high degree of digital competence in terms of strategy, tool use, and autonomy in learning.

In summary, the questionnaire analysis reveals that chatbot adoption among participants was moderate, with just over half reporting active use during the course. While this indicates promising uptake, the relatively high proportion of non-users points to potential gaps in chatbot design, accessibility, or integration into the learning experience. Among those who did use the chatbots, satisfaction levels were notably high, suggesting that the tool was perceived as effective in supporting learning. However, some participants expressed a desire for improved alignment between chatbot responses and course-specific content, highlighting the need for greater contextual relevance. The findings also show that participants engaged with chatbots in diverse and purposeful ways—using them to clarify concepts, generate study materials, and prepare for assessments—all of which support key aspects of Professional Digital Competence (PDC). Additionally, several patterns of use, particularly dialogic engagement and the exploration of alternative perspectives, suggest emerging forms of digital agency. These aspects are discussed in greater detail in Section 5.2.

5.2. Findings from Interviews (Research Question 2: Chatbot Use and Digital Agency)

This section presents findings related to Research Question 2: How did chatbot use contribute to the development of digital agency, as viewed through a cultural-historical perspective? Drawing primarily on the qualitative interview data, the analysis explores how participants appropriated chatbots as cognitive and cultural tools within their learning processes. Thematic analysis of the eight semi-structured interviews revealed three overarching patterns that illustrate different dimensions of digital agency development: (1) metacognitive awareness and self-regulation, (2) critical interaction and tool appropriation, and (3) epistemic engagement and reflective autonomy.

Metacognitive Awareness and Self-Regulation: Several participants described how chatbot interactions encouraged them to monitor their own understanding and learning progress. By prompting the chatbot to explain or rephrase difficult concepts, participants reported greater clarity and confidence in their grasp of the material. These interactions often served as checkpoints for self-evaluation, enabling learners to identify gaps in their knowledge and adjust their study strategies accordingly.

From a cultural-historical perspective, these practices illustrate self-regulated learning mediated by digital tools, in which the chatbot supports both the planning and monitoring students' learning. The chatbot, in this case, functioned as a mediational artifact that scaffolded metacognitive awareness, a key component of digital agency.

Critical Interaction and Tool Appropriation: Participants also demonstrated critical engagement with chatbot responses, frequently evaluating the relevance and trustworthiness of the output. Some described instances where they challenged the chatbot's answers or asked for clarification until the response aligned with their expectations or course content.

Such engagement reflects epistemic agency as learner's ability to question, adapt, and repurpose digital tools to suit their own learning objectives. Rather than passively accepting AI-generated responses, these participants used the chatbot dynamically, taking control of the interaction to extract meaningful learning benefits. This aligns with cultural-historical perspective on tool-mediated learning, where learners actively reshape their interaction with tools based on their evolving needs and socio-cultural context.

Epistemic Engagement and Reflective Autonomy: A smaller group of participants used the chatbot to explore educational content from multiple angles, often engaging in extended dialogue to test ideas or examine alternative interpretations. These learners described chatbot interactions not only as information retrieval, but as a space for conceptual exploration and reflective thinking.

This form of dialogic engagement mirrors the exploratory discourse found in collaborative learning environments and signals a high degree of reflective autonomy. Participants demonstrated the capacity to use the chatbot not just to answer questions but to pose new ones, extend discussion, and reframe their understanding—practices central to transformative digital agency.

In summary, the interview data suggest that chatbot use contributed meaningfully to the development of digital agency among participating teachers. Through scaffolded reflection, adaptive use of AI-generated responses, and epistemic experimentation, learners engaged with chatbots in ways that extended beyond instrumental use. From a cultural-historical perspective, the chatbot functioned as a mediational tool enabling learners to participate in technologically mediated meaning-making, enhance their autonomy, and exercise control over their learning processes.

While not all participants exhibited these behaviours to the same extent, the findings point to the potential of AI chatbots to foster critical, reflective, and agentive learning practices, provided that learners are supported in developing the skills and dispositions to engage with such tools productively. These insights have important implications for the design of professional learning environments that aim to strengthen both digital competence and digital agency.

6. Discussion

This study aimed to explore pre- and in-service teachers' learning experiences with AI chatbots in the ICTPED MOOC, focusing on their usage patterns, perceived benefits, and challenges. The findings align with previous research on the integration of chatbots in online education, reinforcing their role in facilitating learning, enhancing engagement, and providing support across various educational contexts (Fidan & Gencel, 2022; Hew et al., 2023; Sáiz-Manzanares et al., 2023).

6.1. AI Chatbots as Interactive Learning Partners

Consistent with prior studies that highlight chatbots' potential to support problem-solving and personalized learning in STEM and language education (Hew et al., 2023; Jeon et al., 2023), our findings demonstrate that participants used chatbots primarily for clarification and understanding of course content. Many students reported leveraging the chatbots to verify their understanding, clarify complex concepts, and receive tailored explanations. This reflects the adaptive and responsive nature of chatbots, similar to their role in STEM education, where they provide step-by-step guidance to enhance learning outcomes

(Atmosukarto et al., 2021). Additionally, chatbots were utilised for content creation and task assistance, with participants generating assignments, quizzes, and instructional materials. These findings echo research by Chang et al. (2023), who emphasised the scalability of chatbots in MOOCs by assisting learners with course navigation and task completion.

Participants found chatbots beneficial for resource gathering and creating summaries, using them to locate relevant curriculum materials, academic references, and video content. This aligns with previous studies on chatbots' ability to facilitate self-directed learning (Sáiz-Manzanares et al., 2023). Moreover, the ability of chatbots to provide real-time feedback contributed to a more interactive learning environment, supporting both cognitive and metacognitive processes in learning (Du et al., 2021).

6.2. Engagement and Motivation in Digital Learning Environments

The study findings highlight that participants were motivated to use chatbots for various reasons, including curiosity about the technology, positive past experiences, and the ease of communication offered by the tool. These findings resonate with research showing that chatbots enhance learner engagement by providing immediate feedback and promoting interactivity in online courses (Fidan & Gencel, 2022; Cheng et al., 2024). Several participants described their experience as opening "a new world for students," indicating a sense of empowerment and excitement, which aligns with previous studies emphasising the motivational aspects of chatbots in online learning (Wu & Yu, 2024).

Additionally, the chatbot's perceived reliability and accessibility contributed to students' trust in the tool as a valuable resource for online learning. Similar to findings by Han and Lee (2022), who noted that chatbots improve accessibility in large-scale learning environments, participants in our study recognised chatbots as a convenient and efficient means of obtaining support, particularly when instructor availability was limited. The positive impact of chatbots on motivation suggests that AI-driven tools can help sustain student engagement over time, particularly in self-paced learning environments.

6.3. Supporting Self-Regulated Learning and Digital Competence

One of the key findings in this study is the chatbot's role as a communication and brainstorming partner. Participants found chatbots valuable in exploring ideas, refining their understanding, and generating new insights. This aligns with previous research on chatbots' ability to foster self-regulated learning by guiding learners through goal setting, progress monitoring, and reflection (Du et al., 2021; Sáiz-Manzanares et al., 2023). The ICTPED MOOC participants used chatbots to engage in reflective learning processes, confirming prior findings that these tools can act as intelligent learning companions that scaffold the learning process (Engeness & Nohr, 2020).

Furthermore, the chatbot's ability to facilitate metacognitive strategies was evident, as participants used it to test their knowledge, analyse different viewpoints, and generate alternative explanations. This finding is in line with research by Edwards (2015) and Mäkitalo (2016), who emphasise the importance of interactive tools in fostering critical thinking and knowledge construction. However, the effectiveness of chatbot-assisted self-regulated learning depends on learners' ability to critically assess chatbot responses, suggesting a need for explicit instruction on how to effectively engage with AI tools (Engeness & Gamlem, 2025).

6.4. Limitations and Challenges in Using AI-Driven Chatbots

Despite the reported benefits, several challenges were identified in participants' responses. Some students noted concerns regarding the accuracy of chatbot-generated content, aligning with existing literature that highlights chatbots' limitations in providing domain-specific, contextually accurate responses (Lee et al., 2020; Cheng et al., 2024).

This suggests the need for ongoing improvements in chatbot training to enhance content precision and minimise misleading or superficial explanations.

Another key concern is the potential over-reliance on chatbots, which could impact students' critical thinking and problem-solving skills, as highlighted in previous studies (Chang et al., 2023; Wu & Yu, 2024). Some participants expressed hesitation about using chatbots extensively, indicating a preference for traditional learning methods or instructor-led guidance. These findings suggest the importance of integrating chatbots as a supplementary rather than a primary learning tool to balance independent learning with expert guidance.

Additionally, chatbot usability across diverse learner demographics remains an issue. Research indicates that non-native English speakers and students from specific geographical regions experience greater difficulties in using chatbots due to language barriers and cultural differences in communication styles (Han & Lee, 2022). In our study, some participants reported struggling with phrasing their questions effectively, leading to inconsistent chatbot responses. Future research should explore ways to enhance chatbot usability by incorporating multilingual capabilities and adaptive learning features.

6.5. Chatbots as Mediators of Digital Agency Development

The findings of this study contribute to a deeper understanding of how AI chatbots mediate the development of students' digital agency in online learning environments. Drawing on a cultural-historical perspective, we conceptualised agency not as a stable trait of the learner, but as an emergent and relational capacity, shaped through mediated interaction with cultural tools—in this case, chatbots (Vygotsky, 1978; Engeström, 1987; Engeness, 2021a).

In this socio-cultural learning environment (ICTPED MOOC), the chatbot functioned as a cognitive mediator, offering opportunities for learners to engage in reflective inquiry, strategic use of feedback, and iterative meaning-making. Participants' ability to use the chatbot to question, reframe, and evaluate content represents a form of epistemic action mediated by digital technology. This contrasts with traditional learning contexts, where tools often serve only to deliver information passively.

Our findings show that while some learners used chatbots dialogically—to test hypotheses, explore alternative interpretations, and reflect on their own thinking, others engaged more instrumentally or superficially. These differences illustrate that digital agency does not arise automatically from tool use but must be supported through pedagogical design that encourages critical, reflective, and purposeful interaction.

Moreover, while several participants demonstrated metacognitive activity, such as monitoring comprehension or adapting their strategies, others expressed difficulty in phrasing effective prompts or assessing the quality of chatbot responses. These patterns suggest that uneven development of agency may result from differences in teachers' PDC, confidence, or prior knowledge, and highlight the need for explicit scaffolding when integrating AI into professional learning contexts.

Although this study was situated in a MOOC designed to support professional digital competence (PDC), its socio-cultural orientation allowed for more than technical skills development; it enabled learners to participate in a community of digital inquiry, where tools such as chatbots shaped not only what learners knew, but how they came to know it. However, the extent to which this transformative potential was realised varied significantly among participants.

In summary, chatbots served not simply as functional support systems, but as mediational tools within a socio-cultural learning environment, influencing how learners engaged with knowledge and developed digital agency. The emergence of this agency was marked by variation: some learners actively appropriated the chatbot for critical and conceptual learning, while others exhibited more passive or surface-level engagement. These findings reinforce the need to design chatbot-integrated learning environments that are not only technically effective but pedagogically intentionally supporting learners to interact meaningfully, reflect critically, and develop as autonomous digital agents.

7. Implications, Further Research and Conclusions

7.1. Implications and Further Research

The findings of this study have several implications for the implementation of AI chatbots in teacher education and professional development, particularly in socio-cultural learning environments such as the ICTPED MOOC. Both quantitative and qualitative data revealed how learners used chatbots for clarification, assessment preparation, and generation of study resources—practices that aligned with high satisfaction ratings (77.8% reporting strong or very strong satisfaction) and frequent engagement with the tools. These usage patterns informed the development of the implications below.

First, chatbot design should prioritise subject-specific accuracy and contextual sensitivity, particularly in complex domains such as pedagogy and teacher education. Participants' difficulty in phrasing questions and receiving inconsistent responses suggests that current chatbot functionality may not always meet the nuanced needs of professional learners. To address this, developers should integrate domain-specific training data and design prompts that better reflect authentic learning tasks in professional education.

Second, instructional strategies should be designed to promote critical engagement with chatbot outputs. While chatbots were helpful in supporting comprehension and task completion, our findings also highlighted the risk of passive reliance on AI-generated answers. Educators should scaffold student use of chatbots through activities that require comparison of chatbot responses with course materials, prompting learners to reflect on accuracy, relevance, and applicability.

Third, issues related to accessibility and inclusivity must be addressed in chatbot design. The quantitative data showed a nearly even split between users and non-users, suggesting that not all students felt confident or motivated to engage with the tool. Language proficiency and digital literacy were identified as barriers by some participants. As a result, we recommend the development of chatbots with multilingual support, simplified user interfaces, and onboarding materials that support diverse learner profiles. Although participants did not directly request these features, these suggestions emerged from our interpretation of recurring usability issues and are supported by existing literature on inclusive and adaptive AI in education (Ilieva et al., 2023; Wu & Yu, 2024).

Fourth, institutions should provide structured pedagogical support for chatbot use. Our findings revealed that learners are often engaged with chatbots independently, without consistent guidance on how to integrate them into their study routines. Educators should receive training on how to embed chatbot activities into their instructional design, and students should be encouraged to treat chatbots as reflective learning partners rather than automated answer providers.

The cultural-historical perspective adopted in this study has also informed our understanding of how digital agency is shaped through tool-mediated activity. Rather than viewing chatbots as static technologies, we interpreted them as cognitive mediators that helped learners externalise thought, test ideas, and regulate their own understanding. This theoretical lens added value by highlighting the process through which digital agency emerged—not just the outcomes—and underscores the need for future chatbot design to prioritise adaptive interaction, dialogic depth, and transparent scaffolding mechanisms that promote reflective autonomy.

While this study focused on a specific teacher education MOOC, the findings point to several broader directions for future research. First, it would be valuable to investigate how specific chatbot features—such as personalised feedback, conversational depth, multilingual capabilities, and adaptability—affect long-term learner engagement, knowledge retention, and the development of digital agency (Wu & Yu, 2024). Second, future studies could explore the potential of chatbots to foster collaborative learning, examining how these tools function not only in individual reflection but also in group-based digital learning environments. Third, research should consider how the integration of AI tools influences instructional design practices, particularly how educators balance pedagogical intentionality with automation in planning and delivery (Ilieva et al., 2023). Finally, continued attention is needed to address ethical concerns, including algorithmic bias, data privacy, and AI transparency, to ensure that the integration of chatbots into education remains equitable, responsible, and aligned with core educational values (Aguilera-Hermida, 2024; Ilieva et al., 2023).

7.2. Conclusions

By situating chatbot interactions within a cultural-historical framework of digital agency, this research makes a unique contribution to the field of AI in education. Specifically, it highlights how chatbots can serve as mediational tools that not only support Professional Digital Competence (PDC) but also foster transformative digital agency among educators. These findings provide actionable insights for the design of AI-driven tools and professional learning environments, offering a pathway for more equitable, reflective, and impactful integration of chatbots in online education.

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Article

Learning About Alphabetics and Fluency: Examining the Effectiveness of a Blended Professional Development Program for Kenyan Teachers

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Abstract: This study examined the effectiveness of an 18-week online blended teacher professional development program for Kenyan in-service teachers. Also, teachers received instruction on the use of an evidence-based early literacy software program for children. The 94 teachers completed two professional development training modules (alphabetics and fluency) and four surveys (one before and one after each module). Surveys assessed teachers' confidence and knowledge consistent with the primary elements of the TPACK model (i.e., content, pedagogy, technology). Knowledge gains were observed for fluency content, but not alphabetics content. Across the program, there were gains in pedagogical knowledge and teachers' confidence. Given the importance of technology in the present study, additional analyses involving intersections of key elements with technology were examined. Outcomes supported the importance of technological pedagogy for the overarching integrated TPACK model. Overall, the TPD and accompanying course material provided some support for teachers who struggle with literacy instruction.

Keywords: teacher professional development; blended instruction; early literacy; technology integration; global south; TPACK

1. Introduction

Early acquisition of literacy skills predicts subsequent gains in literacy attainment and educational success and provides societal benefits related to occupational, health, and economic gains (DeWalt et al., 2004; Nie et al., 1996). However, fewer than 50% of all Kenyan school students currently meet minimum proficiency requirements in English literacy (The World Bank, 2022). Kenya has two official languages: Kiswahili and English (Kenya Law Reform Commission, 2023), with English serving as the language of instruction after Grade 3. Thus, training in foundational early literacy skills, including alphabetics (e.g., phonological awareness, phonemic awareness, and phonics), fluency, and reading comprehension in English is critical for Kenyan students' future success. This training is best achieved through formal instruction at school by teachers knowledgeable about how to teach early literacy skills effectively (Spernes & Ruto-Korir, 2018). As such, the present study examines the efficacy of an early literacy teacher professional development program (focusing on alphabetics and fluency) offered in a blended format (online and in-person) to support Kenyan teachers in their delivery of early literacy instruction.

1.1. Kenyan Context

In recognition of the need to improve literacy countrywide, the Kenyan government introduced two innovative education initiatives: the Digital Literacy Program and the new Basic Education Curriculum Framework (BECF; Kenyan Institute of Curriculum Development, 2019). The Digital Literacy Program is a multiphase program initiated in 2013 (Keya-Shikuku, 2021). Its ongoing goals involve significant investment in infrastructure to support the use of technology as a teaching and learning tool. Goals included enhanced online connections and the introduction of computer devices (i.e., laptops, tablets) within schools to make quality literacy education more widely available (Barasa, 2021). Realizing this goal, however, has been challenging. Teachers have borne the burden of acquiring the skills to integrate technology in their classrooms (Kerkhoff & Makubuya, 2021), while dealing with a limited number of devices, large class sizes (Heinrich et al., 2019), and limited technological support (Kirimi, 2014).

In addition, teachers face the demands of learning and integrating the new Basic Education Curriculum Framework (BECF; Kenya Institute of Curriculum Development, 2017). The BECF introduces a new curriculum which marks a significant shift in pedagogy from a predominantly transmission-based model to one that is student centered, promotes active learning approaches, and has a focus on inclusion. This new curriculum also prioritizes the development of skills and competencies that are relevant to students' futures in the workforce (Sifuna & Obonyo, 2019). Again, teachers have borne the burden of acquiring the knowledge and skills to be able to integrate these significant changes to content, pedagogy, and methods as part of their teaching practice.

The adoption of the new BECF curriculum, in addition to the push toward digital learning, necessitates opportunities for teachers to receive professional development training to ensure teachers have the resources, knowledge, and support needed to promote teacher agency. Providing such training, however, is a significant task given the number of teachers distributed over such a wide geographic region. Previous training attempts using a cascade model for teacher training have proven ineffective and inefficient (Bett, 2016). The present study explores the impact of teacher professional development using online blended instruction to inform teachers how best to use technology-based tools to support young children's literacy skill development.

1.2. Models of Best Practice: Integrating Technology

The challenges associated with acquiring new domain knowledge and technological skills and integrating these within new pedagogies is significant but not insurmountable. Previous pilot studies suggest that professional development programs, which provide direct instruction about early literacy development as well as pedagogies about student-centered learning, can promote Kenyan teachers' knowledge gains in these domains (e.g., Uribe-Banda et al., 2023). Difficulties in integrating technology as a teaching tool have been found in many contexts, including barriers to technology use by teachers in more technologically literate education systems (Pittman & Gaines, 2015). As a result, a large body of research has emerged in the past 20 years that recognizes the growing need to define and understand the construct of effective technology integration across diverse educational contexts.

Shulman (1986) identified the important distinction between mastery of curricular content (i.e., domain knowledge) and the understanding of how material is best communicated to students (i.e., pedagogical knowledge). He argued for the need for a category of knowledge that involves both content knowledge and pedagogical knowledge together, referred to as content–pedagogical knowledge. In the following decade, new types of technology were introduced to classrooms and among these were computers. Recognizing the new set of skills that technology required of teachers, Mishra and Koehler (2006) proposed a framework for navigating the shifting landscape of educational technology, referred to as the Technological Pedagogical Content Knowledge (TPACK) model. Their framework builds on Shulman (1986) by including a new primary knowledge domain, technological knowledge, in addition to content and pedagogical knowledge. While recognizing the importance of understanding technologies and how they work, TPACK argues that successful educational instruction requires knowledge of what types of technologies are most effective in communicating specific content and how to use them in a way that is consistent with appropriate pedagogical practice (Mishra & Koehler, 2006). Specifically, TPACK argues that content, pedagogical, and technological knowledge are all interrelated and simultaneously involved in the productive use of technology in educational settings.

The three primary knowledge domains, content, pedagogy, and technology, have unique and shared content in the TPACK model. Where the three primary knowledge domains overlap, they create secondary domains. These domains include pedagogical–content, technological–content, technological–pedagogical knowledge, and a final overlapping domain of technological–pedagogical–content involving the intersection of all three primary domains (Mishra & Koehler, 2006). The total structure of TPACK therefore involves seven knowledge domains. Thus, in order to develop a capacity for technological fluency in education, educators must develop technological competence as well as content and pedagogical knowledge.

The present study uses the TPACK model to explore Kenyan teachers' self-efficacy and performance outcomes from a blended online teacher professional development program. Given the rapid expansion of technologies, the technology component of the TPACK model requires continuous consideration (Brantley-Dias & Ertmer, 2013). Technology integration within the context of the present study includes examining blended instruction as the method of instruction for teachers as well as teaching teachers how to integrate software as an instructional tool for their students.

To satisfy the need for effective and appropriate classroom software applications, developers have created evidence-based and evidence-proven resources that follow both content and pedagogical aspects of the TPACK framework. For example, A Balanced Reading Approach for Children Designed to Achieve Best Results for All (ABRACADABRA, ABRA for short; CSLP, 2019) is a freely available software program that offers instructional activities in four main areas of literacy: alphabetics, fluency, reading comprehension, and writing. Developers of the program strongly advocate for purposeful classroom implementation and offer a specialized teacher professional development program freely available for teachers. Positive outcomes for students and teachers following use of the tool and training have been demonstrated in Canada (Savage et al., 2013), Australia (Wolgemuth et al., 2011), and Hong Kong (Mak et al., 2017). Effective use of ABRACADABRA in the classroom requires skill in navigating the program's interface as well as a comprehensive understanding of its literacy content. This customizable feature and the emphasis on teachers' decision making regarding how to best integrate the technology as part of ongoing instruction resonate strongly with expectations that promote teachers' agency. Biesta et al. (2015) identify teachers' ability to actively "(shape) their work and its conditions—for the overall quality of education" (p. 624) as key to teacher agency. For this reason, ABRACADABRA is a valuable tool for teaching literacy and for fostering teacher agency, especially when delivered in a student-centered context such as the one defined by the new curriculum (BECF) and consistent with the pedagogies provided through the teacher training program. ABRA's activities provide varying levels of difficulty which allows it to be tailored to the needs of individual students. Through the use of an assessment report feature, teachers can receive summaries of student activity and performance within ABRA.

This enables them to monitor student time spent completing specific ABRA activities, along with error detection, and make decisions regarding the instructional needs of individual students or within their class more generally. Teachers are able to differentiate their instruction for those students who might need additional or less exposure to one or more of the ABRA activities or, conversely, benefit more from teacher-led whole-class instruction. Availability of resources is one of several key elements impacting teachers' agency as is the culture or values in the current context (Biesta et al., 2015). Thus, the combination of the software resources and the cultural shift to student-centered instruction in the teacher professional development programming provides the tools teachers can use to "shape" the instructional environment for students. In the present study, the teacher professional development program provided the additional resource of targeted instruction regarding alphabetics and fluency as these skills are foundational to early literacy development.

Children must acquire alphabetics knowledge (letter-sound knowledge, phonological and phonemic awareness) to learn to read (Ehri et al., 2001; Martinussen et al., 2015). However, teachers find it difficult to understand and teach concepts such as phonological awareness (Binks-Cantrell et al., 2012; Joshi et al., 2009). Additionally, fluency must be acquired after children learn to read words in order to understand the text (Paige, 2020). In the present study, the accompanying teacher professional development program for the alphabetics and fluency concepts were adapted to meet the needs of Kenyan teachers. Specifically, the aspects of the new Kenyan curriculum as well as supports for novice users of technologies as teaching tools were incorporated. The design of the professional development program drew upon previous pilot studies with revisions to accommodate suggested areas for improvement (Uribe-Banda et al., 2023). Thus, the present study examines Kenyan teacher outcomes when provided with two of the four revised online teacher training modules (alphabetics and fluency). The present study uses the TPACK framework as it permits all of the key elements (content, pedagogical, and technological knowledge) of the teacher professional development training to be examined together.

1.3. Present Study

The present study examines change in teacher knowledge and perceptions regarding early literacy development and skills following participation in a blended online teacher professional development program introducing content specific to alphabetics and fluency. In the context of Kenya's new curriculum and technology investments, assessing teachers' pre- to post-intervention knowledge will help to identify current needs and guide future intervention development. Because student-centered pedagogy and educational technology are both recent introductions to Kenya's school system, the guiding principles of TPACK are highly relevant. Specifically, the question of whether knowledge integration necessarily follows the development of basic competencies is of critical importance to the success of Kenya's initiatives and for the promotion of teacher agency going forward. Thus, a key goal was to observe changes in teachers' perceived knowledge, confidence, and comfort for teaching the two early literacy domains of alphabetics and fluency, as well as the pedagogies that support learning and use of technologies such as ABRA.

The overarching research question was: are there pre-test/post-test changes in alphabetic and fluency knowledge following participation in the professional development program? Given previous research, it was expected that explicit instruction and training regarding development of early literacy skills would yield pre-test to post-test gains in alphabetics knowledge (H1). It was also expected that the program would yield learning gains in teacher fluency knowledge (H2).

An additional research question explored the integration of the three core primary domain areas of the TPACK model, that is, teachers' technological, pedagogical, and literacy-content knowledge. Based on the intersecting structure of the TPACK model (Mishra & Koehler, 2006), strong relationships between primary and secondary domains were expected post-intervention (H3). Secondary knowledge domains were also expected to be strongly related to teachers' integration when all domains overlap (i.e., technological–pedagogical–content knowledge), as indicated by the TPACK model (Mishra & Koehler, 2006). The present study introduced an online instructional tool for teacher learning and software that teachers could use for children's learning with some in-person sessions. Given this focus on technology, combined with recent technology-based infrastructure changes introduced by the Kenyan government, examining the technology-related aspects of the TPACK model was an important criterion for the present study.

In summary, the present study examined three hypotheses related to the impact of a teacher professional development program for Kenyan teachers regarding early literacy instruction.

2. Method

2.1. Participants

The 94 (66 females, 28 males) in-service teachers were recruited from public schools in coastal and south-western regions of Kenya. Targeted regions were selected to ensure representation across urban, peri-urban, and rural communities. Following approvals from local county government agencies, surveys of the schools' IT infrastructure were completed. Invitations were sent to the head teachers in those schools with the necessary IT infrastructure, who in turn solicited voluntary participation from their early primary teachers. Teacher's ages ranged from 21–58 years (M_{age} = 37.55, SD_{age} = 7.17), with females being slightly older than males (M_{female} = 38.66, vs. M_{male} = 35.04; $t(90) = 2.28$, $p = 0.025$). Most participants had completed a university or college program (70.2%) with the remaining participants having completed some university (26.6%) or high school (1.1%). All participants had completed teacher's college.

Teaching experience ranged from 1–35 years ($M_{experience}$ = 11.13 years, $SD_{experience}$ = 7.05), with female teachers reporting more years of teaching experience than males ($M_{females}$ = 12.08, M_{males} = 8.89; $t(89) = 2.00$, $p = 0.048$). The number of students taught ranged from 17–126 while completing the alphabetics module ($M_{students}$ = 57.78, $SD_{students}$ = 21.71) and 10–130 for the fluency module ($M_{students}$ = 54.97, $SD_{students}$ = 21.97). Most participants (77.6%) spoke at least 3 languages.

Almost two thirds of the teachers (60.6%) reported previously taking an online course while 74.5% reported previously taking a specialized reading instruction course. Fewer than a quarter of the teachers (22.3%) reported having prior experience using ABRA[1]. This research was reviewed and approved by a university research ethics board and all participants were treated in accordance with APA/CPA ethical principles.

2.2. Materials

Participants completed two sets of pre- and post-surveys, one set for the alphabetics module and one set for the fluency module. Pre-surveys were completed prior to training for each module and post-surveys were completed after training for each module. Only the alphabetics pre-survey assessed demographic information (i.e., age, gender, years teaching). Both the alphabetics and fluency pre- and post-surveys assessed content knowledge specific to the respective module. The pre- and post-alphabetics and post-fluency surveys assessed a combination of primary and secondary TPACK knowledge domains. Several self-report items included on the fluency surveys were adapted from previous research (Schmid et al., 2020; Bingimlas, 2018), and items on the alphabetics surveys were original.

2.2.1. Content Knowledge

The same measures were used in both the pre- and post-alphabetics surveys to test knowledge gains regarding alphabetics concepts. Three multiple-choice questions assessed knowledge of phonological awareness, phonemes, and phonics. Participants also completed a phoneme counting task. Together, these four performance measures constitute some of the core areas of foundational alphabetics knowledge and reflect the content presented in the first module. The four alphabetics items were aggregated for an alphabetics content performance score (maximum = 4).

Five multiple choice questions were used on both the pre- and post-fluency surveys to assess fluency knowledge gains. These involved defining fluency, accuracy, and partner reading, selecting effective strategies for teaching fluency, and identifying features of a book repository that would enhance promotion of early fluency instruction. These items were aggregated to create a fluency content knowledge performance measure (maximum score = 5).

In addition, four items assessed participants' self-reported ability to understand, speak, and write in English using a 10-point scale (1 = *not at all fluent* to 10 = *very fluent*) on the pre-alphabetics survey. Reliability calculated using Cronbach's $\alpha = 0.94$ indicated a high level of internal consistency. Participants also rated three items assessing their knowledge of fluency using a 6-point scale (1 = *I need a lot of additional knowledge* to 6 = *I have strong knowledge*) on the post-fluency instruction survey. Reliability was good, Cronbach's $\alpha = 0.84$.

2.2.2. Pedagogical Knowledge

Two multiple choice questions on the pre- and post-alphabetics surveys tested pedagogical knowledge gains. These performance measures targeted teachers' knowledge of student-centered pedagogy and included defining differentiated instruction and identifying four relevant components of self-regulated learning from a list of seven items. Two additional multiple-choice questions on the post-alphabetics survey measured pedagogical knowledge specific to the ABRA software (i.e., correctly categorizing an ABRA instructional activity and selecting the most effective teaching strategy for using ABRA in a classroom).

Four items adapted from Schmid et al. (2020) assessed self-reported pedagogical knowledge on the post-fluency survey. Reliability for these adapted measures was acceptable $\alpha = 0.71$. Participants indicated their agreement (1 = *strongly agree* to 5 = *strongly disagree*) with statements concerning the depth, intentionality, and flexibility of their teaching approach.

2.2.3. Technological Knowledge

Self-reported technological knowledge was assessed in the pre- and post-alphabetics and post-fluency surveys. In the pre-alphabetics survey, participants rated their level of comfort (1 = *very uncomfortable* to 5 = *very comfortable*) when using six different technological resources: the internet, computers/tablets, WhatsApp, online modules, email, and Zoom. Reliability was acceptable, $\alpha = 0.74$. In the post-alphabetics instruction survey, six questions asked participants to rate their comfort regarding various navigational and problem-solving tasks when using the ABRA software (e.g., navigating the ABRA activities when I am teaching the children) on a 5-point scale (1 = *not at all comfortable* to 5 = *extremely comfortable*). Reliability was acceptable, $\alpha = 0.78$. Participants also indicated the average number of times ABRA was typically used with their class per week.

Four items adapted from Schmid et al. (2020) assessed self-reported technological knowledge on the post-fluency survey in the current study. Reliability for these adapted measures was high, $\alpha = 0.93$. Participants rated their knowledge of information and communication technologies (e.g., *I can solve ICT related problems*, *I know websites about new* *technologies*) using a 6-point scale (1 = *I need a lot of additional knowledge* to 6 = *I have strong knowledge*).

2.2.4. Technological–Pedagogical Knowledge

Self-reported technological–pedagogical knowledge was assessed through three questions on both the pre- and post-alphabetics surveys. Participants indicated their level of agreement (1 = *strongly disagree* to 5 = *strongly agree*) regarding their ability to supervise students using technology, use technology during lessons, and plan lessons using technology. These items together reflect key competencies for effectively integrating classroom technologies and demonstrate acceptable face validity. Reliability was acceptable in the pre-alphabetics survey (α = 0.78) but lower in the post-alphabetics survey (α = 0.52).

Four items adapted from Schmid et al. (2020) assessed self-reported technological–pedagogical knowledge in the post-fluency survey. Participants indicated their level of agreement (1 = *strongly disagree* to 5 = *strongly agree*) about the use of technology to support/enhance student learning. Reliability was good, α = 0.80.

2.2.5. Pedagogical–Content Knowledge

Self-reported pedagogical–content knowledge was assessed through 11 items in the pre- and post-alphabetics survey. Reliability was high for both measures α = 0.90/0.92, respectively. Participants rated their confidence (1 = *not at all confident* to 6 = *very confident*) in teaching 11 different literacy skills (e.g., segmenting/ blending).

2.2.6. Technological–Content Knowledge

Six items adapted from Bingimlas (2018) assessed self-reported technological–content knowledge in the post-fluency survey. Participants rated their knowledge (1 = *I need a lot of additional knowledge* to 6 = *I have strong knowledge*) of how to use technology to study, explore, and illustrate fluency (3 items; e.g., *I know websites with materials for studying fluency*) and alphabetics (3 items; e.g., *I know websites with materials for studying alphabetics*) content (Cronbach's α = 0.89/0.88 for each measure, respectively).

2.2.7. Technological–Pedagogical–Content Knowledge

Three items adapted from previous research (Schmid et al., 2020) assessed self-reported technological–pedagogical–content knowledge in the post-fluency survey. Participants indicated their agreement (1 = *strongly disagree* to 5 = *strongly agree*) with statements concerning their ability to effectively use technology to enhance literacy instruction (e.g., *I can choose ABRA activities that enhance what I teach, how I teach, and what students learn;* Cronbach's α = 0.70).

2.3. Procedure

Teachers participated in two training modules totaling 18 weeks in duration. First, teachers completed the 12-week alphabetics teacher professional development module followed by the 6-week fluency module. To increase the contextual relevance, specific connections between the TPD content and the BECF English Language curricula were established with supplemental support material. Consistent with blended instruction, the blended format in the present study included three in-person sessions for each module: the initial, middle, and final sessions. All other sessions were completed online using web conferencing software, with WhatsApp being used for ongoing interactions with the facilitators and with the teachers' colleagues. Additionally, teachers met with colleagues (and in some cases, their head teachers) within their school or within a cluster of schools to share lesson plans and implementation strategies related to the use of ABRA in their literacy teaching. Participants were grouped into three cohorts to allow for ease in delivery.

Start dates were staggered across the three cohorts during the 2022 and 2023 Kenyan school year. For each module, the pre-survey was completed on the first day of instruction and the post-survey was completed on the last day or shortly thereafter. Surveys were completed independently online. TPD requirements included the completion of online quiz-styled scavenger hunts designed to encourage interaction with the TPD instructional content and the activities within ABRA and READS and submission of lesson plans that included the integration of ABRA and/or READS. For example, scavenger hunts included a small number of questions varying in difficulty from factual to applied questions (e.g., "How many phonemes does the word 'pitch' have?" for the topic related to phonemic awareness). Teachers prepared a final teaching portfolio following an in-person showcase event at the end of each module, where participants came together to share experiences. Discounted data bundles were provided to participants to facilitate the completion of course requirements and surveys. For those teachers with unstable connectivity, TPD content could be exported in the form of PDF documents.

3. Results

3.1. Teacher Perceptions: Self-Reported Knowledge and Confidence

Teachers' self-ratings regarding their English skills (i.e., content knowledge), confidence in teaching English (i.e., pedagogical–content knowledge), and ability to use technology in their classroom (i.e., technological–pedagogical knowledge) were converted to proportion scores to permit comparisons across measures (see Table 1). Overall, 94.9% of teachers provided ratings above the midpoint of the scale indicating fluency in English and a high degree of comfort across all types of technology and apps. Within the confidence measure for teaching English ($M_{pre\text{-}instruction}$ = 0.84 to $M_{post\text{-}instruction}$ = 0.87), confidence ratings were highest for individual items assessing teaching English letter names ($M_{pre\text{-}instruction}$ = 0.90, *SD* = 0.16) and teaching letter sounds ($M_{post\text{-}instruction}$ = 0.90, *SD* = 0.14) and lowest for instruction for writing stories ($M_{pre\text{-}instruction}$ = 0.70, *SD* = 0.24) and teaching the mechanics of writing ($M_{post\text{-}instruction}$ = 0.80, *SD* = 0.17).

Table 1. Means and Standard Deviations for Self-reported Pre- and Post-Alphabetics Instruction Measures (maximum score of 1).

Knowledge Domain	Pre-Alphabetics	Post-Alphabetics
	Mean (*SD*)	Mean (*SD*)
Technological (General)	0.88 (0.10)	-
Technological (ABRA)	-	0.79 (0.13)
Content (English skills)	0.84 (0.16)	0.88 (0.15)
Pedagogical–content (Confidence teaching English)	0.84 (0.13)	0.87 (0.11)
Technological–pedagogical	0.86 (0.20)	0.87 (0.14)

After completing the fluency module, teachers reported high levels of pedagogical and technological–pedagogical knowledge as well as confidence in their ability to use technology to effectively deliver fluency-content material to their students (i.e., technological–pedagogical–content knowledge) with means all at or above M = 0.91 (see Table 2). Teachers' self-ratings for knowledge in the domains of technological, content (i.e., fluency), and technological–content knowledge, however, were lower (i.e., highest $M_{fluency\ content}$ = 0.69)

Ratings of technological knowledge were not normally distributed, with most ratings falling equally at both 0.33 (15.3%) and 0.83 (15.3%).

Table 2. Means and Standard Deviations for Self-reported Post-Fluency Instruction Measures.

Knowledge Domain	Post-Fluency-Instruction	
	Mean (*SD*)	n
Technological (General)	0.64 (0.23)	72
Pedagogical	0.92 (0.10)	71
Content (Fluency)	0.69 (0.12)	86
Technological–content	0.60 (0.24)	77
Technological–pedagogical	0.93 (0.12)	73
Technological–pedagogical–content	0.91 (0.12)	81

Given this distribution for self-ratings of technological knowledge, teachers were assigned to one of two groups based on their technological knowledge ratings and *t*-tests were conducted to investigate whether teachers with low technological knowledge and high technological knowledge provided different ratings of their technology-integrated knowledge (i.e., technological–content knowledge and technological–pedagogical knowledge). Teachers with ratings at or below the median ($Mdn = 0.71$) were categorized as less technologically fluent, and those with ratings above the median were categorized as more technologically fluent. The homogeneity of variance assumption was met for both analyses. Ratings of technological–content knowledge ($M = 0.74$, $SD = 0.19$) and technological–pedagogical knowledge ($M = 0.95$, $SD = 0.11$) were significantly higher for technologically fluent teachers in comparison to technologically non-fluent teachers ($M = 0.44$, $SD = 0.19$ and $M = 0.89$, $SD = 0.13$; $t(61) = 6.26$, $p < 0.001$, $d = 1.58$ and $t(62) = 1.89$, $p = 0.032$, $d = 0.47$, respectively).

3.2. Teacher Performance Outcomes: Pre- and Post-Instruction Differences

Pre-post performance did not yield expected increases (H1) for content performance scores in alphabetics ($M_{pre\text{-}test} = 2.57$, $SD_{pre\text{-}test} = 0.87$; $M_{post\text{-}test} = 2.78$, $SD_{post\text{-}test} = 1.00$; $t(57) = 1.18$, $p = 0.122$, $d = 0.15$) but did yield gains (H2) for fluency knowledge ($M_{pre\text{-}test} = 2.59$, $SD_{pre\text{-}test} = 0.95$; $M_{post\text{-}test} = 3.17$ $SD_{post\text{-}test} = 1.11$; $t(87) = 4.04$, $p < 0.001$, $d = 0.43$). A third *t*-test indicated pre-post-instruction gains ($M_{pre\text{-}test} = 0.90$, $SD_{pre\text{-}test} = 0.63$; $M_{post\text{-}test} = 1.19$, $SD_{post\text{-}test} = 0.65$) in pedagogical knowledge ($t(80) = 3.00$, $p = 0.002$, $d = 0.33$).

To allow for comparisons across domains over time, all performance measures were converted to proportion scores (see Table 3). Measures of alphabetics and fluency competence on the pre- and post-surveys were aggregated as a total content performance measure.

Table 3. Means and Standard Deviations for Pre- and Post-Instruction Performance Proportion Scores.

Knowledge Domain	Pre-Instruction	Post-Instruction
	Mean (*SD*)	Mean (*SD*)
Aggregated Content	0.59 (0.14)	0.66 (0.17)
Alphabetics	0.63 (0.22)	0.70 (0.24)
Fluency	0.52 (0.19)	0.63 (0.22)
Pedagogical	0.45 (0.31)	0.58 (0.33)

A 2 (Time; Pre-instruction, Post-instruction) × 2 (Domain: Content, Pedagogical) repeated measures ANOVA was conducted to assess differences in performance across time and domains. All assumptions were met and the ANOVA revealed a significant main effect of time ($F(1, 50) = 7.99$, $p = 0.007$, $\eta p^2 = 0.14$). As expected, teachers' post-instruction performance scores were significantly higher than their pre-instruction performance scores. There was also a main effect of domain on performance scores ($F(1, 50) = 8.25$, $p = 0.006$, $\eta p^2 = 0.14$), such that teachers' content knowledge performance scores were significantly higher than their pedagogical performance scores. There was no interaction of time and domain ($F(1, 50) = 0.59$ $p = 0.447$, $\eta p^2 = 0.01$).

A 2 (Time: Pre-instruction, Post-instruction) × 2 (Technological fluency: Low, High) mixed model ANOVA was conducted to assess differences between low and high-technological fluency and teachers' total content knowledge gains. Residuals were normally distributed, and the homogeneity of variance assumption was met. The main effect of time and technological fluency and technological fluency by time interaction were non-significant ($F(1, 43) = 3.71$, $p = 0.061$, $\eta p^2 = 0.08$; $F(1, 43) = 0.16$, $p = 0.688$, $\eta p^2 = 0.00$; $F(1, 43) = 0.25$, $p = 0.619$, $\eta p^2 = 0.01$).

3.3. Correlations Among Domains

3.3.1. Alphabetics

Correlations for the pre- and post-alphabetics survey correlations are presented in Tables 4 and 5, respectively. At pre-instruction, only two correlations were significant. Self-reported pedagogical–content knowledge was positively correlated with self-reported content knowledge and negatively correlated with content knowledge performance.

Table 4. Pre-alphabetics Survey Correlations.

Measures	1	2	3	4	5	6
1. Technological (General)	1					
2. Content	−0.247	1				
3. Pedagogical–content	0.018	0.456 **	1			
4. Technological–pedagogical	0.556 **	−0.013	0.081	1		
5. Alphabetics (performance)	−0.066	−0.228	−0.314 *	0.029	1	
6. Pedagogical (performance)	0.091	0.086	−0.106	−0.107	0.085	1

* $p < 0.05$; ** $p < 0.001$.

Table 5. Post-alphabetics Survey Correlations.

Measures	1	2	3	4	5	6	7
1. Technological (ABRA)	1						
2. Technology Use	0.432 **	1					
3. Content	0.374 **	0.081	1				
4. Pedagogical–content	0.403 **	0.311 **	0.205	1			
5. Technological–pedagogical	0.471 **	0.252 *	0.267 *	0.354 **	1		
6. Alphabetics (performance)	0.184	0.103	0.420 **	−0.041	0.079	1	
7. Pedagogical (performance)	0.051	−0.251 *	0.158	0.025	0.032	0.248 *	1

* $p < 0.05$; ** $p < 0.001$.

At post-instruction, self-reported technological–pedagogical knowledge was positively correlated with technological knowledge. However, the relationships among all other primary–secondary domain groupings were not significant. With respect to performance measure scores, teachers' alphabetics performance was positively correlated with self-reported content knowledge. Technology use was positively correlated with self-reported technological knowledge but negatively correlated with pedagogical performance.

3.3.2. Fluency

Results of the post-fluency-instruction correlation analyses are presented in Table 6. Both self-reported technological–content knowledge and self-reported technological–pedagogical knowledge were positively correlated with their corresponding primary domains (i.e., technological and content knowledge; technological and pedagogical knowledge). Self-reported technological–content knowledge was also negatively correlated with technology use. Both secondary domains were positively correlated with self-reported technological–pedagogical–content knowledge. With respect to performance knowledge scores, content knowledge performance was not correlated with any domain.

Table 6. Post-Fluency-Instruction Correlations.

Measures	1	2	3	4	5	6
1. Technological (use)	1					
2. Pedagogical	0.037	1				
3. Content	0.041	0.205	1			
4. Technological–content	0.271 *	0.213	0.668 **	1		
5. Technological–pedagogical	0.141	0.457 **	0.176	0.266 *	1	
6. Technological–pedagogical–content	−0.050	0.554 **	0.207	0.270 *	0.460 **	
7. Fluency (performance)	0.045	0.062	0.060	−0.099	−0.030	1

* $p < 0.05$; ** $p < 0.001$.

The correlation analysis assessing content knowledge performance between the fluency and alphabetics performance ($r(78) = 0.08$, $p = 0.489$) was not significant.

3.4. Predicting Secondary Domain Knowledge After Completing Both Modules

Technological knowledge and pedagogical knowledge were entered into a hierarchical regression analysis to determine primary domain knowledge predictors of technological–pedagogical knowledge (see Table 7). Initially technological knowledge was entered in the first step while pedagogical knowledge was entered as the second step. The two variables mentioned above explained a significant amount of the variance in technological–pedagogical knowledge, total $R^2 = 0.331$, $F(2, 53) = 13.14$, $p < 0.001$. Technological knowledge was significant as the first step. Pedagogical knowledge explained 24.1% unique variance, $\beta = 0.493$, $t(55) = 4.37$, $p < 0.001$. For completeness the order of entry of the variables was reversed and technological knowledge explained 6.4% unique variance in technological–pedagogical knowledge, $\beta = 0.254$, $t(55) = 2.25$, $p = 0.028$.

Table 7. Predictors of technological–pedagogical knowledge (total $R^2 = 0.331$).

Step and Variables	ΔR^2	β	*t*-Value	*p*-Value
1. Technological	0.091	0.301	2.32	0.024
2. Technological		0.254	2.25	0.028
Pedagogical	0.241	0.493	4.37	<0.001
1. Pedagogical	0.267	0.517	4.44	<0.001
2. Pedagogical		0.493	4.37	<0.001
Technological	0.064	0.254	2.25	0.028

Technological knowledge and content knowledge were entered into a hierarchical regression analysis to determine predictors of technological–content knowledge (see Table 8). Initially, technological knowledge was entered as the first step while content knowledge was entered as the second step. The two variables mentioned above explained a significant amount of the variance in technological–content knowledge, total $R^2 = 0.574$,

$F(2, 59) = 39.74$, $p < 0.001$. Technological knowledge was significant as the first step. Content knowledge explained 12.7% unique variance, $\beta = 0.428$, $t(61) = 4.19$, $p < 0.001$. For completeness, the order of entry of the variables was reversed. Technological knowledge was also a unique statistical predictor as the second step, $\beta = 0.432$, $t(61) = 4.24$, $p < 0.001$, predicting 13% unique variance.

Table 8. Predictors of technological-content knowledge (total $R^2 = 0.574$).

Step and Variables	ΔR^2	β	*t*-Value	*p*-Value
1. Technological	0.447	0.669	6.963	<0.001
2. Technological		0.432	4.239	<0.001
Content	0.127	0.428	4.194	<0.001
1. Content	0.444	0.666	6.924	<0.001
2. Content		0.428	4.194	<0.001
Technological	0.130	0.432	4.239	<0.001

Technological–pedagogical knowledge and technological–content knowledge were entered into a hierarchical regression analysis to determine predictors of technological–pedagogical–content knowledge (see Table 9). Initially, technological–pedagogical knowledge was entered as the first step, while technological–content knowledge was entered as the second step. The two variables explained a significant amount of the variance in technological–pedagogical–content knowledge, total $R^2 = 0.216$, $F(2, 58) = 7.99$, $p < 0.001$. Technological–pedagogical knowledge was significant as the first step. Technological–content knowledge was not a significant predictor of unique variance ($\beta = 0.128$, $t(60) = 1.06$, $p = 0.292$). For completeness, the order of entry of the variables was reversed. Technological–pedagogical knowledge was a unique statistical predictor, $\beta = 0.414$, $t(60) = 4.24$, $p = 0.001$, predicting 15.9% unique variance as the second step.

Table 9. Predictors of technological–pedagogical–content knowledge (total $R^2 = 0.216$).

Step and Variables	ΔR^2	β	*t*-Value	*p*-Value
1. Technological–pedagogical	0.201	0.448	3.85	<0.001
2. Technological–pedagogical		0.414	3.43	0.001
Technological–content	0.015	0.128	1.06	0.292
1. Technological–content	0.057	0.240	1.90	0.063
2. Technological–content		0.128	1.06	0.292
Technological–pedagogical	0.159	0.414	3.43	0.001

4. Discussion

A key goal of the present study was to assess the effectiveness of a blended online teacher professional development program for improving teacher perceptions and knowledge related to two critical domains in early English literacy instruction, specifically alphabetics and fluency. Additionally, the study adopted the TPACK model (Mishra & Koehler, 2006) as a framework to assess relationships among the primary areas, specifically content, technology, and pedagogy, and secondary areas, which include the overlap of the primary areas that serve as the building blocks for successful integration of technology as a teaching and learning tool. Outcomes from the present study suggest that teachers' skills, experiences, and confidence can be facilitated through exposure to the blended online teacher professional development program provided in the present study. Gains across domains, however, were not equivalent. Examination of primary and secondary domains consistent with the TPACK components suggests a more nuanced understanding may be necessary to identify areas of ongoing need.

4.1. Changes in Domain Knowledge

Previous pilot research by Uribe-Banda et al. (2023) suggested that exposure to a blended teacher professional development program can yield knowledge gains in key literacy domains such as alphabetics and fluency. Teachers in the present study did not follow this pattern of outcomes. Instead, significant gains were observed for content related to fluency but not for alphabetics. One explanation for the differences in outcomes may be that gains in the previous research may have overestimated the efficacy of the teacher professional development for alphabetics instruction. Specifically, in that pilot study the gains noted were modest, moving participants from just below to just above the midpoint of measured scales, and these gains were based on a very small sample (Uribe-Banda et al., 2023). In the present study with a much larger and more generalizable sample size, when similar measures were used, the mean alphabetic performance scores started at just above the midpoint of the scale and ended just slightly higher but still near the midpoint of the scale with differences in these two scores not being statistically significant. Our outcomes are consistent with a body of research suggesting that acquisition of key constructs related to phonological, phonemic, and grapheme–phoneme awareness may be especially challenging for teachers. Specifically, several studies suggest that many teachers, not just those in Kenya, lack sufficient knowledge of the underlying linguistic concepts needed to effectively teach early literacy (Binks-Cantrell et al., 2012; Joshi et al., 2009; Martinussen et al., 2015) as well as lack awareness of their actual phonological awareness skills (Carson & Bayetto, 2018). This explanation is consistent with Wawire (2021) who suggests that insufficient exposure to literacy concepts in pre-service education programs leaves teachers unprepared to teach literacy skills. Consistent with previous literature, our findings suggest that teachers may need greater exposure, deeper and more thorough instruction, and more opportunities for hands-on practice with these constructs than was available through the professional development modules used in the present study. For example, a successful TPD program that targeted the use of phonics included 30 weeks of intervention and biweekly visits by mentors (Ehri & Flugman, 2018), suggesting that TPD in the area of phonological awareness might require intensive, long-term instruction. Additional ways of addressing the need for greater exposure to difficult constructs, such as the difference between phonological and phonemic awareness, would be important to explore in future research. For example, in future iterations of the present program it may be useful to incorporate additional videoconferencing sessions targeting these concepts. Alternatively, teachers may need more gradual exposure to the concepts over time through additional modules especially if the modules are leveled to permit teachers to advance according to their level of understanding of these concepts. Additional modules could provide more intensive instruction and practice, and this could be augmented if accompanied by regular mentoring.

While these findings suggest gaps in teacher knowledge, it is also important to consider that deep awareness of linguistic concepts may not be necessary for early literacy instruction. In the present study, exposure to foundational alphabetics constructs was extended both in terms of content presented and time given to cover this domain. These changes from previous teacher professional development designs, however, did not result in improved knowledge for teachers. Thus, it may be important to determine just how much and how deeply teachers need to understand constructs related to alphabetics to produce high-quality instruction. It could be that moderate awareness of these challenging linguistic underpinnings is sufficient to inform good teaching practice, especially when teachers have access to high-quality software teaching tools (e.g., ABRA). A deeper understanding of the theoretical underpinnings, although desirable theoretically, may not be necessary in terms of teaching practice.

Although teachers showed no gains in alphabetic knowledge, teachers did demonstrate knowledge gains with respect to the domain of fluency. These gains reflect greater understanding of the constructs of speed, accuracy, and expression relative to those associated with alphabetics. However, it is also possible that our results reflect an order effect where discussions involved in the coverage of alphabetics influenced subsequent acquisition of fluency content. Order of presentation in the professional development program was fixed, aligning with research that children must be taught and learn alphabetic skills prior to developing reading fluency. It may be useful in future research to teach these domains separately to assess their individual impact on teachers' learning gains.

4.2. Teacher Perceptions and Performance

At the start of the teacher professional development, teachers reported a high level of confidence across all domains but scored poorly on all (content and pedagogical) performance measures. This disconnect between confidence and performance replicates previous research (Binks-Cantrell et al., 2012; Carson & Bayetto, 2018; Joshi et al., 2009; Uribe-Banda et al., 2023) where perceived skills are inflated relative to performance outcomes. Teachers in the present study were experienced and were engaged in teaching early literacy skills in their classrooms prior to participating in the program. Thus, teachers may have based initial confidence ratings on their perceived current success in the classroom. However, exposure to the content and feedback through assignments, quizzes, and discussions during the teacher professional development program could have highlighted gaps in their knowledge which could account for their lowered subsequent confidence ratings.

Interestingly, teachers with lower alphabetics scores reported greater confidence in providing literacy instruction to students. This finding suggests that teachers with a strong foundation of alphabetics knowledge are more likely to recognize the difficulty of communicating key literacy concepts effectively to students. In support of this interpretation, literacy-pedagogical confidence was not significantly related to literacy confidence after exposure to the course material. As emphasized by the TPACK framework, both content knowledge and pedagogical competence together involve flexible use of content expertise along with strategic teaching methods (Mishra & Koehler, 2006). Thus, the complexity of alphabetics concepts, which involves learning linguistics concepts, may have prevented teachers from developing knowledge specific to the content domain. Further evidence of this view was provided post-fluency-instruction, where perceptions of fluency and fluency-pedagogical competence were strongly correlated following significant performance gains.

At the outset of the study, teachers' pre-instruction technological comfort was positively related to technological–pedagogical knowledge, suggesting that teachers who were comfortable using technology also felt comfortable supervising students and planning lessons using technology. However, although teachers generally reported a high degree of technological comfort pre-instruction, distinct groups characterized by lower and higher technological fluency ratings emerged following completion of both modules. A comparison of the two groups revealed significant differences in both measures of technology-integrated secondary knowledge (i.e., technological–pedagogical and technological–content). Less technologically fluent teachers reported less confidence in their teaching and fluency abilities when involving technology. This finding highlights the importance of developing a strong foundation of technological knowledge. As Kenyan policy further increases expectations of a technology-integrated classroom, it is critical that teachers receive adequate technological training to ensure the quality of instruction is maintained. An important next step would be to prepare technology training modules that range from basic (e.g., log in, familiarity with hardware, basic troubleshooting) to more sophisticated skills (e.g., flexible use of navigation tools, adapting software) to ensure all teachers have the skill sets needed to confidently use technologies.

Teachers' use of ABRA in the classroom offered a different perspective on the relationship between technology and pedagogy. Following exposure to the alphabetics module, teachers who used ABRA more frequently scored lower on pedagogical performance. It is possible that, for lower-performing teachers, increased use of ABRA compensated for weaker teaching practices or poorer understanding of how to integrate the concepts and technologies. Reliance on using ABRA without having an understanding of the content or pedagogy may have limited teachers' opportunities to practice instructional methods associated with student-centered pedagogy. Alternatively, ABRA may be highly valued as a teaching aid by teachers who are struggling to adapt to the new BECF curriculum. This perspective is further supported by the strong relationship between ABRA use and confidence on each self-evaluation measure, suggesting that use of supportive technology may encourage greater perceived teaching competence across domains.

Importantly, teachers' pedagogical performance scores increased over the course of the alphabetics module. This is an important shift in knowledge especially in the Kenyan context as the student-centered pedagogical approach is a core aspect of Kenya's new curriculum (BECF). These findings are encouraging as they indicate that the explicit instruction and practice offered through the training provided support for teachers in their transition toward translating key elements of the new curriculum into practical active-learning opportunities for children.

4.3. Predicting Self-Reported Secondary Domain Knowledge After Completing Both Modules

An important consideration in assessing the impact of the teacher professional development programming was determining how, and whether, specific aspects of learning were potentially driving observed changes in self-reported outcomes. Adopting the TPACK components as a foundation for assessing outcomes permitted a finer-grained analysis of what teachers were experiencing and how these experiences were related. In this study, both technological knowledge and content knowledge were significant predictors of, and accounted for a similar amount of variability in, technological–content knowledge.

Similarly, technological knowledge and pedagogical knowledge both contributed to technological–pedagogical knowledge. Together these outcomes support the integrative aspects of the TPACK components for the effective integration of technology as a teaching and learning tool.

Technological–pedagogical knowledge, but not technological–content knowledge, was a significant predictor demonstrating unique variance in relation to the full model which encompassed technology, content, and pedagogy. Therefore, when examining the contributions of technology, pedagogy, and content knowledge, for the implementation and use of a technology program, the ability to use technology to teach is crucial and appears to be more important than understanding the links between technology and content knowledge. These findings point to the contributions of an evidence-based, evidence-proven software program, such as ABRA, in enhancing literacy instruction. The ability to implement a software program to teach early literacy skills might be the initial step to enhancing literacy skills and, more broadly, addressing global concerns such as the United Nations Sustainable Development Goal 4 which cites the need to provide inclusive, equitable, quality education (UNESCO, 2016). This software may be a particularly useful instructional tool for teachers who have challenges in relaying literacy content that requires a deep understanding of underlying literacy concepts (e.g., phonological processing).

4.4. Limitations and Future Directions

The present study draws upon a body of research indicating that online blended instructional approaches can serve as important instructional tools (Bicen et al., 2014; Means et al., 2013). However, the absence of a control group potentially limits our understanding of the full impact of the intervention. Future studies incorporating a no-exposure or waitlist control as a benchmark would provide additional confidence for interpreting study outcomes. It may also be useful to introduce varying levels of in-person contact as part of the blended model. This would allow for a better understanding of the optimal amount of support needed by teachers to maximize outcomes. In addition, the teachers in this study met with their colleagues within their school or across a cluster of schools to discuss ABRA-infused pedagogical experiences as the TPD unfolded. However, providing structured opportunities for teachers to engage in broader discussions about their teaching and their understanding of education in general where the sharing of these beliefs would allow them to embed the professional development training within a broader professional context and could further facilitate their sense of agency going forward (Biesta et al., 2015).

The present study examines the current sample of teachers as a group even though there are individual differences including years of teaching experience, age, technological experience, and gender. It may be important in future research to explore the impact of these individual differences with respect to teachers' perceptions and performance in the TPD to determine whether subgroups of teachers benefit more or less from aspects of such training. In addition to these quantitative data it may also be useful to incorporate interviews with teachers following each module to gain a richer understanding of their experiences.

5. Conclusions

Teachers in Kenya, and beyond, constantly face changes to curriculum content, pedagogy, and ongoing advancements in technologies. As the tools for teaching and learning continue to shift there is a need to develop viable, accessible, evidence-based, and proven supports to help teachers address these changes. In Kenya, where academic content is delivered in English, effective early literacy skills instruction leading to reading success is critical (Spernes & Ruto-Korir, 2018). The present study provides partial support confirming the efficacy of a blended teacher professional development program for teachers who provide instruction in early literacy skills. However, findings also make it clear that some skills—especially those associated with alphabetics—require further support for teachers to attain mastery. Meeting the needs of teachers to integrate content, pedagogical practice, and technological tools is critical. The use of the TPACK model as a frame for designing and evaluating teacher professional development programs can provide insights regarding program strengths and weaknesses and thus may be an important tool for designing and evaluating future programs, especially those involving digital delivery or support tools. The present study demonstrated the importance of examining all components of the TPACK framework when evaluating the effectiveness of a teacher professional development program for building teachers' knowledge and skills regarding the principles of early literacy instruction.

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Notes

1 Although individual difference measures were collected, the smaller sample size prohibited statistical analysis of the impact of these variables. See the Limitations and Future Directions section for further discussion.

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