



Venturing into the Unknown: Critical Insights into Grey Areas and Pioneering Future Directions in Educational Generative AI Research

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Abstract

Advocates of AI in Education (AIEd) assert that the current generation of technologies, collectively dubbed artificial intelligence, including generative artificial intelligence (GenAI), promise results that can transform our conceptions of what education looks like. Therefore, it is imperative to investigate how educators perceive GenAI and its potential use and future impact on education. Adopting the methodology of collective writing as an inquiry, this study reports on the participating educators' perceived grey areas (i.e. issues that are unclear and/or controversial) and recommendations on future research. The grey areas reported cover decision-making on the use of GenAI, AI ethics, appropriate levels of use of GenAI in education, impact on learning and teaching, policy, data, GenAI outputs, humans in the loop and public–private partnerships. Recommended directions for future research include learning and teaching, ethical and legal implications, ownership/authorship, funding, technology, research support, AI metaphor and types of research. Each theme or subtheme is presented in the form of a statement, followed by a justification. These findings serve as a call to action to encourage a continuing debate around GenAI and to engage more educators in research. The paper concludes that unless we can ask the right questions now, we may find that, in the pursuit of greater efficiency, we have lost the very essence of what it means to educate and learn.

Keywords Artificial intelligence in education · Future research directions · Generative artificial intelligence (GenAI) · Grey areas · Higher education

Introduction

“How do we use and teach our students to use tools that we don't really understand ourselves?”

- Sarah Honeychurch.

Generative artificial intelligence (GenAI) has already been integrated (albeit to varying extents) into many sectors of human society, including education. The use of

GenAI tools has been so widespread that some of them have become normalized, and, hence, invisible (U.S. Department of Education Office of Educational Technology, 2023, p. 3). By invisible, we mean that people use them without realizing the existence of an AI layer in the process. Even popular media sources are publicly reporting on this, and according to Hale (2024), GenAI “has integrated so seamlessly into various aspects of our lives that it's often gone unnoticed” (n. p.). For instance, Microsoft, Baidu, and Google have all used GenAI technology in their web search engines as a conventional feature that is taken for granted. While the societal impacts of GenAI may be transformative, much remains

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unknown about this technology, which still functions as a black box in many respects. And most of the promises of GenAI (if not all) are yet to be supported by valid (and long-term) research-based evidences (Stracke, 2024). For this reason, it is critically important that GenAI should undergo rigorous evaluation and research so that it can meet the specific needs of the special sector—education and that we can harness its benefits while mitigating potential risks (Birhane & McGann, 2024). As Widder and Hicks (2024) caution, “today’s hype will have lasting effects that constrain tomorrow’s possibilities” (p. 6). Nevertheless, although GenAI offers promising solutions to numerous societal challenges, it is seldom questioned whether and to what extent it may itself contribute to the very problems it seeks to address and to pose new questions (Schütze, 2024).

While the far-reaching social and educational implications of previous technological revolutions are still evolving, educators now find themselves abruptly entering the so-called GenAI revolution, which “may make the others look minor by comparison” (Giannini, 2023, p. 2). The amount of attention and media focus that GenAI has garnered over the past couple of years stresses the urgency to investigate both what educators currently know—and what they do not yet understand—about GenAI in education. Moreover, it is critical to explore what educators believe they need to learn in order to maximize the benefits and mitigate the challenges of this potentially transformative technology in their teaching practices.

Why this Study?

Arguably, the affordances of GenAI may include personalizing and democratizing learning experiences for every student, assisting teachers in routine tasks, and streamlining education management and administration (Molina et al., 2024). Given its possible role in transforming education in unpredictable ways, it has triggered immediate, strong and widespread reactions in the education community (Bozkurt et al., 2024; Klopfer et al., 2024; Smith-Mutegi et al., *in press*). However, this community has yet to make sense of its implications for education (Mamo et al., 2024). The debate around GenAI has “spiraled out of control, with many otherwise sober commentators reaching extreme conclusions over the transformative connotations of this technology” according to Selwyn (2024) who “calls for more reasoned responses to the educational possibilities of AI” (p. 4).

This study is part of a multi-phase project in response to this call (Bozkurt et al., 2024). It aims to fill the gap of the relative lack of educators’ voice in the literature of GenAI in education (Chiu et al., 2023) by describing and analyzing their perspectives on these technologies. Current research is limited and is often fixed to particular cases, subject areas,

or contexts. For example, a study conducted by Kim et al. (2022) elicited the views and perspectives of 10 leading teachers about key considerations for the integration of AI in education (AIEd) in K-12 educational contexts. While this study presented relevant findings to support student-AI collaboration in K12 classrooms, additional research that includes educator’s perspectives is necessary to support these findings and to explore different school settings and broader contexts.

A more comprehensive and systematic literature review conducted by Chiu et al. (2023) set out to explore the opportunities and challenges of AI in AIEd in published studies of diverse educational contexts with various aims from 2012–2021. Findings indicate mostly positive attitudes toward the use of AI to support teaching and learning. However, most educators in the studies reported also described reservations and reluctance to use AI due to concerns associated with the limitations and potential harms. Drawing on Holstein et al., (2019) and others, this systematic review importantly emphasizes a “lack of education perspectives in AIEd research” and the need to capture more because most published literature “fails to capture the perspectives of educational researchers and teachers” (p. 13). Chiu et al. (2023) go on to recommend that “future studies should investigate new research methods for interdisciplinary studies of AIEd that can actively engage teachers...” (p. 13), further supporting the need for the unique research pursued in this project.

Results of this project are reported in three papers. The current paper focuses on the following two aspects: the participating educators’ perceived grey areas (i.e., issues that are unclear and/or controversial) and their recommended directions for future research. The Findings and Discussion section of this paper is organized into gray areas and future research directions. Gray areas present issues that collectively intrigue the participants and explain the ways they are uncertain about these issues according to data analysis. Future research directions present the participants’ collective recommendations on what warrants (further) exploration to ensure that GenAI can become a conducive technology for education. The other two papers concentrate on (1) positive and negative AI (Bozkurt et al., 2024) and (2) human-AI interaction, respectively. To date, aside from this project, there is currently no other existing published research on AIEd that uses collective writing as a method of inquiry.

Methodology

Research Paradigm

Adopting a qualitative and interpretive research paradigm, this study considers collective writing as a method of inquiry (Gale & Bowstead, 2013) in a persistent pursuit

of meaning-making (Jandrić et al., 2023). Collective writing can contribute to the co-construction of knowledge and wisdom (Burns et al., 2023) by merging diverse ideas and strands of thinking into a coherent whole (Jandrić et al., 2023; Peters et al., 2022), resulting in a synergy that can overcome individual limitations. Within such a paradigm, the main goal of writing-centered research is to generate understanding. Our collective knowledge and wisdom is here applied to help shape the ongoing discourse and bring informed, critical perspectives to the ongoing impact of GenAI in education, including research design, data collection and analysis.

Research Design, Data Collection and Analysis

A modified Delphi technique (see Pelletier et al., 2021) was employed to align with the research paradigm chosen. Specifically, a structured process was used to gather informed, collective judgments from a panel of experts in the form of a questionnaire survey. Delphi was chosen as the main research instrument since it encourages reflection on one's own perspectives and the contributions of others, and encourages the development of views from the individual towards the collaborative and collective.

Experts who accepted the invitation to participate in this study were asked to express their views on semi-structured open-ended questions independently, with no knowledge of who else was involved and what other participants said, in a survey using Google Forms. They could add to their original inputs if they so wished before the closure of the survey. Put specifically, they were asked to share what they thought regarding 1) the positive roles that GenAI might play in education, 2) its potential negative implications for education, 3) problems that might arise in human-GenAI interaction, 4) issues that were controversial and 5) areas that need further research. Findings from the first two questions have been published (Bozkurt et al., 2024). The current paper reports on the last two questions, as pointed out earlier.

The study participants consisted of 47 educators with expertise in the use of technology in education who are also the researchers of the current study. This duality of roles aligns with hallmarks of the research paradigm of collective writing and is seen as a strength of this methodology. A possible limitation of this approach that must be acknowledged, though, is that the views collected as data and presented in the findings may not be balanced enough (Greene, 2014; Lapadat, 2017). However, with 47 educators in different subject areas with different socio-cultural backgrounds involved, biases that may exist are not any single individual's. Instead, in addition to mitigating individual biases, they reflect the collective value propositions, which aligns well with the purpose of this study and the value inherent in collective writing as a method of inquiry (Gale & Bowstead, 2013).

Thematic analysis of the participants' responses was conducted (Braun & Clarke, 2006). The collected data were coded, with themes and subthemes identified. Following an open coding process, the first author coded and categorized the data into themes manually. Some themes that were categorized into a higher-level theme became the subthemes of this high-level theme. The second author then verified the results by reading the materials and the extracts pertinent to each (sub)theme, and resolved several disagreements through discussion. The final list of (sub)themes was shared with the panel to ensure that they represent the shared understandings of the panel. Additionally, the collective paper writing and editing phase helped us refine our thinking further, which is also part of the thematic analysis process.

Findings and Discussion

Grey areas

Grey areas reported by the participants are grouped into nine themes, three of which are composed of eight subthemes, as depicted in Fig. 1. It is worth noting, though, that some of the themes may overlap with each other. However, each has its own distinctive focus.

Decision-making On the Use of GenAI

The source of authority for making decisions on the use of GenAI in education remains unclear: Using GenAI in education not only involves investment by educational institutions but may also have cost implications for students. In the latter case, issues of practical relevance include how students can access GenAI on an equitable basis, whether they will be punished or suffer consequences for using or not using GenAI, when they can or cannot use GenAI, and even whether GenAI is necessary in education. Despite the spiraling "AI-fever" (Selwyn, 2024, p. 4) in the educational landscape, there is no consensus on who has the (final) authority to make decisions concerning these issues.

AI ethics

AI ethics remains a grey area despite a long history of philosophy that is concerned with how technology can and ought to be incorporated into education institutions (Swindell et al., 2024), along with the existence and emergence of relevant policies, frameworks, and guidelines: Ethical considerations are mostly confined to evaluative or judgment statements which tend to truncate discourse and research (Downes, 2023; Moore & Dousay, 2024; Moore & Tillberg-Webb, 2023), leading to a gap between armchair ethics and applied ethics. Ethics should not be solely about critiques.

Fig. 1 Themes and subthemes of grey areas

- Decision-making on the use of GenAI
- AI ethics
- Appropriate levels of use of GenAI in learning
 - Assessment
 - Autonomy
- Impact on learning and teaching
 - Cognitive activities
 - Personalization versus standardization
 - Student-teacher relationship
 - Mission/purpose of education
- Uncertainty surrounding the need for new GenAI policies
- Data collection and use
- GenAI outputs
 - Ownership and authorship
 - Quality
- Human in the loop and human-AI interaction
- Public-private partnership

Instead, ethics should be embodied in practice and inform principles for practice (Stracke et al., 2024b). Education, and EdTech specifically, are trailing other disciplines such as medicine, business and engineering in their serious integration of ethics into curricula, decision-making, design models and practice (Moore, 2005, 2021; Moore & Ellsworth, 2014; Stracke, 2024). It is thus no wonder that AI ethics remains a grey area to educators.

Appropriate Levels of Use of GenAI in Learning

This theme is further divided into two subthemes: assessment and autonomy.

Assessment The extent of appropriate use of GenAI in assessment remains a grey area: Despite the disruptive effects of GenAI on assessment, there remains confusion about what constitutes acceptable use of GenAI, use which spans across a spectrum from improving one's writing with GenAI assistance, to idea generation, to document creation. In addition, there is no consensus on how much AI assistance is appropriate for different types of course activities and assessments. Such issues may cause significant problems when it comes to considering what constitutes authorship and plagiarism. Unless adequately addressed, this could escalate into a cat-and-mouse game of detecting and evading detection of GenAI-generated texts, a dynamic that resembles a generative adversarial network and may result in better detection and evasion tools, but does little to address the fundamental issue of encouraging students to engage actively with the learning process. AI in assessment is one of the four main roles of applying AI to student learning

(Chiu et al., 2023). Notwithstanding all the captivating affordances, numerous issues are still unclarified (Gardner et al., 2021; Swiecki et al., 2022), including those reported above by the participants of this study.

Autonomy How to balance GenAI guidance with student autonomy in learning processes remains unclear: Over-reliance on AI support may pose risks to human autonomy by hindering students' independent learning, active construction of understanding, and critical thinking, among other things (Prunkl, 2024). While some researchers have argued that AI use is appropriate when it promotes humanizing ends and helps students engage with the world (Swindell et al., 2024), it remains unclear what the right mix of GenAI support and independent or self-directed learning is to produce the best learning outcomes and to strengthen students' perceived self-efficacy or beliefs in their capabilities to exercise control over their own learning activities (Arhin, 2024). Research into GenAI's AI's impacts on student autonomy is still understandably rare. This is because "autonomy is a core value that is deeply entrenched in the moral, legal, and political practices of many societies" (Prunkl, 2024, p. 1).

Impact On Learning and Teaching

This theme is subdivided into four themes: cognitive activities, personalization versus standardization, student-teacher relationship and mission/purpose of education.

Cognitive Activities Whether and how GenAI facilitates or impedes cognitive selection, integration and organization is an issue of uncertainty and controversy: It is unclear how

GenAI will impact existing human practices and understandings. We have yet to come to evidence-based conclusions on the effects of GenAI on student learning and development, including mental health and psychological well-being, particularly in the long term (McGrath et al., 2024; Monett & Paquet, 2024; Perrotta, 2024). These effects, whether positive or harmful, are often claimed but not yet proven. Against this backdrop, questions remain about how we should change our pedagogies to improve the quality at all educational levels, from policy through to curricula and teaching.

Personalization Versus Standardization There is no consensus on how to balance personalization and standardization: Personalization is often posed as an attractive selling point of GenAI. It is commonly advocated and eagerly pursued in education and thanks to GenAI, the utopia of personalized education seems within reach in some people's eyes (Bozkurt et al., 2024; Crompton & Burke, 2024; Pelletier, 2024; Watters, 2021). Nevertheless, there is a risk of neglecting a standardized curriculum that ensures a common educational foundation (Xiao, 2024a). It is also important to acknowledge that AI-enabled personalization is not the same as human-facilitated personalization (Porayska-Pomsta, 2023). Further, personalization is not always a good thing from the perspective of what education is for (Xiao, 2024b) in that it can fulfil Biesta's (2009) qualification function of education at best but do little to the other two functions- socialisation and subjectification, as argued below. However, even in regard to the qualification function, issues such as what should be personalized and based on what, when and how, among other dimensions remain unclear and controversial (Tlili et al., 2024).

Student–teacher Relationship It is unclear how GenAI will change the student–teacher relationship and whether for better or worse: Each new turn in simplifying access to information changes the dynamics and sociocultural foundations of interaction between student and teacher in that it reduces the former's dependence on the latter in obtaining knowledge. What role are teachers supposed to play in a world where students grow up with an AI personal tutor? How does pedagogy change with the potential loss of intersubjective relationships? How do students and teachers perceive each other when their first point of contact in an educational transaction is GenAI rather than humans? Questions like these have yet to be answered with confidence (McGrath et al., 2024; Tarc et al., 2024; UK Department for Education, 2024), hence causing confusion among educators.

Mission/purpose of Education The use of GenAI exacerbates the confusion about the mission or purpose of education: GenAI tools could be very powerful and effective

teachers, especially of hard skills and competencies (Trust et al., 2023). Nevertheless, the attitudes and values they model—the tacit curriculum—are not entirely human, and will inevitably shape the humans who learn from them (Dron, 2023). This impact on our collective psyche shapes the mission of education (Sriprakash et al., 2024). Is education always quantifiable and measurable? Are soft skills and competencies part of education? What do we want to prepare our students for? Of the three functions of education that Biesta (2009) argues for (i.e., qualification, socialisation and subjectification), as argued previously, GenAI can at best serve the qualification function by providing students “with the knowledge, skills and understanding and often also with the dispositions and forms of judgement that allow them to ‘do something’...” (p. 39). It can hardly contribute to socialization—educating students to “become members of and part of particular social, cultural and political ‘orders’” (Biesta, 2009, p. 40) and subjectification—allowing students to “become more autonomous and independent in their thinking and acting” (p. 41). There is a lack of common understanding of these issues which are fundamental to some other themes discussed in this paper and warrant further attention.

Uncertainty Surrounding the Need for New GenAI Policies

The extent to which new policies are needed is yet to be clarified: It is generally agreed that GenAI policies are needed at governmental and institutional levels to regulate and govern GenAI technology (Williamson et al., 2024). However, what types of policies are needed for which context (i.e., within classroom teaching, co-creation of teaching, homework use, etc.) and to what extent? Issues concerning this question remain unclear, particularly given that many applications of AI have implications usually addressed by existing operational policies. For example, although almost all universities have policies to deal with plagiarism and cheating, there is no consensus on whether new policies are needed to address what may constitute plagiarism and cheating brought about by GenAI or how well existing policies can cope with this problem. On the other hand, educational policy on the use of GenAI generally lags behind rapid advancements in GenAI technologies. Further, whether regulation and governance will promote or hinder innovation constitutes another controversial issue (Williamson et al., 2024).

Data Collection and Use

Data is a grey area with multifaceted issues: Who owns the data generated by students, teachers, and/or other stakeholders? Who owns the data generated by AI interactions? Who decides how to use the data collected? Who decides what data will be used to train a model? How is user privacy

protected rather than compromised or monetized? These are issues of much controversy (Birhane & McGann, 2024; Picasso et al., 2024; Riley & Bruno, 2024). Informed consent should not be the pretext to justify the misuse of educational data; it tends to leave the false impression that the real data owners know how their data is or will be used and what data is or has been collected (Bozkurt et al., 2024). In reality, it is not unusual that people are forced to give their consent if they want to use GenAI or that they are misled about what they consent to because they are not adequately informed.

GenAI Outputs

This theme is composed of two subthemes: ownership and authorship as well as quality.

Ownership and Authorship Ownership or authorship is no longer a clear-cut concept when it involves the use of GenAI: What does it mean to own or to author work? Where is the dividing line across my ideas expressed differently through AI, and AI output expressed as my ideas? Who owns AI-generated educational content? Can GenAI claim (co-) authorship when it is used to create or to help create content? Is it an act of plagiarism if the content contains other people's copyrighted work, especially without their permission or knowledge? How do we deal with issues pertaining to copyright and intellectual property? How do we define the acceptable use of GenAI in academic publishing? How and when do authors report their use of GenAI? Questions such as these need to be addressed but remain mostly unsolved (Bozkurt, 2024a; Floridi, 2024).

Quality The quality of GenAI outputs remains controversial with implications for its applicability: It is no secret that GenAI may have hallucinations, tell lies, make errors, have biases or create deepfakes (Bozkurt, 2023). However, there is uncertainty on how and to what extent this instability may affect educational outcomes. Quality assurance cannot be overemphasized because “current forms of generative AI may lead to forms of educational delegation that undermine personal and social responsibility, exacerbating educational harms ‘downstream’; that is, at the point where the behaviour of a model meets real life” (Perrotta, 2023, p. 62).

Humans in the Loop and Human-AI Interaction

The imperative to keep humans in the loop in most tasks seems to be universally acknowledged and yet the optimal balance in human and AI complementarity in educational settings remains undefined: As discussed in detail by Cukurova (2024), “at best, the current complementarity paradigm is to make a better match of what humans can do and what AI can do with the problems to be tackled to achieve

productivity gains at tasks rather than making humans more intelligent” (p. 12). This is a problematic positioning particularly for education in which human development is one of the primary goals. What are the effective ways of combining GenAI capabilities and human intelligence to achieve specific educational objectives? How do we set the limits of GenAI decision-making to prevent overriding human roles and autonomy? Who (human or GenAI) does what and why? Who (human or GenAI) is to be held accountable? What are the possible patterns of human-AI interaction and how do these patterns affect teaching dynamics? Educators have not come to grips with “the role and impact humans and AI may play in educational settings” (Memarian & Doleck, 2024, p. 1).

Public-private Partnership

While public-private partnerships may be deemed essential to the deployment of GenAI in education, it remains uncertain how to balance the agenda of public good and the pursuit of commercial profits: Public-private partnerships are the norm today. In fact, the private sector has always been the most influential force behind GenAI in education, holding sway on governments' educational policies. The field is increasingly dominated by only a few tech giants and driven by profit, not the need to educate. Due to their profit-seeking nature, it is unrealistic to expect private investors to favor the common good over their own economic interests. However, how we should balance the private sector's interest and the public good agenda that education is supposed to serve remains a grey area. To what extent should we depend on external providers? How do we make sure—through legislation and best practices—that the needs of learning and teaching rather than commercial interests drive the development of GenAI in education? How can equal access to the best GenAI tools be guaranteed for all people where the best tools are not restricted behind paywalls? Clarifying this partnership is crucial for ensuring the use of GenAI for the common good (Molina et al., 2024; Williamson et al., 2024).

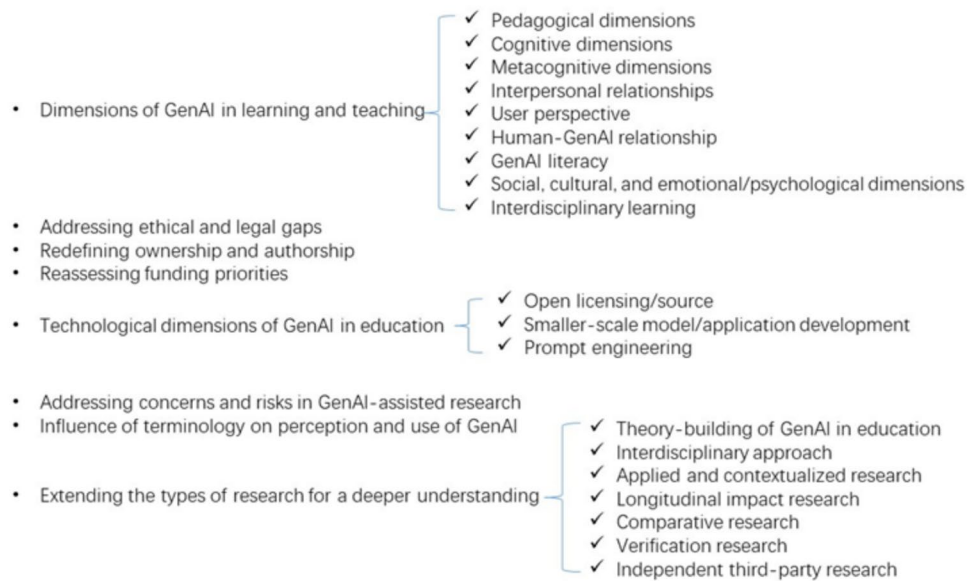
Future Research Directions

Directions recommended by the participants for future research are categorized into eight themes, three of which are composed of 19 subthemes (see Fig. 2). As in the case of grey areas, some of the themes may overlap with each other. However, each has its own distinctive focus.

Dimensions of GenAI in Learning and Teaching

This theme consists of nine subthemes: pedagogical dimensions, cognitive dimensions, metacognitive dimensions, interpersonal relationship, user perspective, human-GenAI

Fig. 2 Themes and subthemes of future research directions



relationship, GenAI literacy, Social, cultural and emotional/psychological dimensions and interdisciplinary learning.

Pedagogical Dimensions Exploring the impact of GenAI on pedagogies is a valuable direction for future research: Given the emerging nature of GenAI, issues concerning pedagogies using GenAI need to be identified and explored. For example, how can GenAI play a role in improving and iterating existing pedagogies? What should GenAI be used to do and not to do? What pedagogical errors, myths or misbeliefs do GenAI reproduce? How valid, reliable and trustworthy are assessments created with GenAI? How can GenAI aid in the development of dynamic and adaptable curricula? How can GenAI support context-specific instructional and assessment design? How are different patterns of GenAI use related to different learning outcomes? How suitable and effective is GenAI as personal tutors when used by students of different educational levels and disciplinary backgrounds? How can GenAI be designed beyond just providing answers? GenAI tools fundamentally differ from human educators (Birhane & McGann, 2024) and often lack education perspectives in their design and development (Chiu et al., 2023). Teachers need yet to understand how to integrate and use GenAI in their pedagogies (Stracke et al., 2024a, 2024b; UK Department for Education, 2024).

Cognitive Dimensions Investigations into the cognitive processes of students interacting with GenAI can contribute to better-informed practice: For GenAI to facilitate learning, it is imperative to understand the mental models that students develop when engaging with GenAI tools (McGrath et al., 2024; Perrotta, 2024) and examine whether and how GenAI may allow students to skip over mid-range skills and move

directly to higher-order thinking (Monett & Paquet, 2024). For example, what would be the consequences and risks if we were to delegate reading, writing and even thinking to GenAI? Such questions are definitely worth exploring.

Metacognitive Dimensions Metacognitive skills are essential to students' creativity and critical thinking as well as learning effectiveness, and so examining GenAI's potential role in supporting students to build and develop their metacognitive skills is essential: How can GenAI be used to enhance students' ability to reflect on and regulate their own learning processes? In what ways does GenAI influence students' critical thinking skills? Which metacognitive skills can benefit from the use of GenAI? Which cannot? The impact of GenAI on metacognition warrants further scrutiny (Molenaar et al., 2021).

Interpersonal Relationships Future research could focus on the relational aspects of learning and teaching: Relational aspects are a distinctive feature of education. How does GenAI change the way students interact with their peers and teachers? How does GenAI change the way teachers interact with each other? What impacts does this shift, if any, in patterns of interpersonal interaction have on learning outcomes? What roles should teachers play in GenAI-mediated learning and teaching? How should they play these roles? For example, is timely, instant feedback always more conducive to learning than somewhat delayed feedback? Which kinds of learning tasks can benefit from instant feedback and which cannot? Which kinds of learning tasks can benefit from GenAI-mediated student–student interaction and which cannot? How does GenAI-mediated teacher-to-teacher interaction impact teacher professional development? These

issues of concern are also identified in other studies (for example, McGrath et al., 2024; Tarc et al., 2024; UK Department for Education, 2024) but need further research.

User Perspective User perspectives on the use of GenAI in education warrant further exploration: GenAI discourse is currently dominated by big tech companies and we need more than ever to hear from educators and learners about their perceptions and lived experience (Chiu, 2024). While it is easy to assume how GenAI is being used in education, it is critically important to continue investigating the diversity of uses instead of making assumptions (UK Department for Education, 2024). For example, how is GenAI perceived and used by students with different social and cultural capital, different motivations, different learning approaches or different personalities? What do students want to know about GenAI? What do students want to use GenAI to do? How is GenAI perceived and used by teachers with different disciplinary backgrounds, different age ranges, different genders or different levels of professional experience? What are the problems that they try to address through GenAI in their teaching? What expectations should students have about their AI use in educational contexts, and what part should educators play in preparing students for baseline AI use in their studies? Finally, it is equally important to learn about the perceptions of education managers, administrators and organizational leaders.

Human-GenAI Relationship Centering studies on the relationship between humans and GenAI will provide deeper insights: It is relevant to explore how humans can team up with GenAI to make the best of it, thereby, informing educational practices. Human agency should not be compromised in any way and human responsibility in all stages of the development, implementation, permission and use of GenAI needs to be recognized (Stracke, 2024). Instead of positioning GenAI as an autonomous entity independent of human influence, research should extend beyond GenAI as an educational technology to emphasize the relationship between humans and technology (Bozkurt & Sharma, 2024; Doshi & Hauser, 2024). Since education is complex, Huang et al. (2023) further highlight that such a relationship between humans and machines should go beyond simple collaboration to achieve some sort of “synergy”, where their combined effect is greater than the sum of their separate effects to effectively achieve the desired learning outcome. For example, how can GenAI help us with basic tasks without jeopardizing creativity? How can GenAI be designed to allow users to have control over its use such as revising the output and giving feedback on the system easily? How can GenAI be so designed as to enable students to exercise their agency in personalizing learning rather than have their learning personalized for them by the machine? Until we have an

in-depth understanding of the human-GenAI relationship, we may not be able to give full play to the affordances of GenAI for education.

GenAI Literacy Dimensions of AI literacy, specifically GenAI literacy, need to be explored in future research: Given the increasing use of GenAI in education, more research on this theme is imperative (Brew et al., 2023; Greene & Crompton, 2025). This includes conceptualizing or defining GenAI literacy in the context of similar contemporary literacies (i.e., digital literacy, critical media literacy, information literacy) and proposing a model or framework for GenAI literacy (Picasso et al., 2024; Varsik & Vosberg, 2024). This model could also extend beyond theory to operationalize GenAI literacy with practical recommendations for educators. A case in point is Bozkurt’s (2024c) 3wAI literacy framework. For example, what are the most fundamental AI literacies and how can these be taught? How can students be taught to critically engage with GenAI? Should we be teaching meta-skills such as “AI collaboration”, where students learn not just to use GenAI, but to understand its limitations, biases, and how to direct it appropriately? How can GenAI be introduced to students safely and effectively so that they fully comprehend ethical biases and risks? What do teachers need to know about these technologies? How do we teach our students to use technologies we do not really understand ourselves? Solutions to these issues should be informed by robust research outcomes.

Social, cultural and emotional/psychological dimensions Examining the social, cultural and emotional/psychological dimensions of GenAI-mediated education is crucial: Education is socially, culturally and emotionally/psychologically motivated; it is not merely about the dissemination of knowledge (Biesta, 2009; Monett & Paquet, 2024; Xiao, 2024a). To what extent does GenAI catalyze paradigm shifts in these dimensions? What are the goals of education? Should the goals of education be re-imagined? How can GenAI be leveraged to promote collaborative learning and foster inclusive learning environments? What are the effects of overdependence on GenAI as a personalized, intelligent tutor? How does GenAI impact the mental health and psychological wellbeing of both students and teachers? How does GenAI affect their identity formation and sense of agency? GenAI systems often exhibit biases that reflect the liberal, Western, pro-capitalist worldview of their creators, and since these biases come from an automated process rather than a human, they can be mistakenly perceived as more objective (Mollick, 2024). We must recognize the biases in GenAI results and their influence on teaching and learning while also attempting to find ways to ameliorate them.

Interdisciplinary Learning Incorporating the use of GenAI to support interdisciplinary learning is a worthwhile inquiry for future studies: Interdisciplinary learning is taken to be essential for the twenty-first century so that students will be better prepared for the real world because expertise and collaboration across organizational or disciplinary boundaries is most often distributed (Smith et al., 2024). GenAI can be used to support interdisciplinary teaching by encouraging teachers “to break the boundaries of disciplines to deliver more interdisciplinary instruction in classrooms” and by encouraging students “to apply what they have learned from different disciplines [and output data sources] to solve complex problems” (Chiu, 2023, p.10). Despite these promising studies, there remains a dearth of research into this topic and more coordinated, multidisciplinary research is essential.

Addressing Ethical and Legal Gaps

It is imperative to understand the ethical and legal implications of GenAI in education: As educators understandably rush to design uses of GenAI in many contexts of learning and assessment, little focus is given to the legal and ethical consequences of the use of commercial tools like ChatGPT in the contexts of mandatory use for students. This is an urgent area of consideration at present (Patil, 2024; Sharma & Sayed, 2024). Ethical questions include: How can we make sure that GenAI practices are fair and responsible as well as safe and secure? How can we avoid an increasing digital divide caused by GenAI? Legal issues include: What kind of regulation do we need for GenAI use in education? When the use of GenAI in education involves young learners, future research should also include parental rights and responsibilities, not only because education is a human right but also because it has implications for “parental (educational) professionalization” (Hartong & Manolev, 2023, p. 5).

Redefining Ownership and Authorship

Highlighting the issue of ownership and authorship in the realm of GenAI is important for future research: Contents and ideas may be the outputs of the interplay between numerous uncredited sources or human–machine collaboration (Bozkurt, 2024a). How do we define originality? How do we acknowledge ownership? How are concepts like originality and plagiarism challenged by GenAI outputs that may reproduce texts or images from their training data? The paradigm of content supply and demand is also undergoing transformation and “deserves a thorough examination across multiple domains” (Floridi, 2024, p. 9).

Reassessing Funding Priorities

Examining the hierarchies in education funding can provide valuable insights: For example, an examination of local versus larger government representation in decision-making in the realm of GenAI is needed. Cutting-edge technologies such as GenAI are exceptionally expensive (Widder & Hicks, 2024; Xiao, 2024b). Nonetheless, it is often taken for granted that funding is not an issue (Xiao and Bozkurt, 2025). Unless adequately addressed, it can exacerbate existing inequity in education as well as undermine the sustainability of GenAI-enhanced education (Varsik & Vosberg, 2024; Xiao, 2023b).

Technological Dimensions of GenAI in Education

This theme is divided into three subthemes: open licensing/source, smaller-scale model/application development and prompt engineering.

Open licensing/source Research into open licensing and open source developments will contribute to the field's advancement: Things have changed across services with the use of GenAI. How should this be reflected in open licensing and open source? We should investigate current (technology and license conditions of) open source AI services to find out how they can be combined; how data and results can be transferred, shared and re-used among them; and how we can use them to establish an open public infrastructure worldwide. For example, it would be a worthwhile investment to design, develop and implement common AI services as community-cloud services and evaluate their potentials, acceptance and impact. These issues have already caught researchers' attention but should be further explored (Blagaila, 2023; Liesenfeld & Dingemane, 2024; Walsh, 2023).

Smaller-scale Model/application Development Future research should deal with the development of smaller-scale models or fine-tuning existing models, using high-quality academic data for specific use cases and within local contexts: Such an endeavor stands in contrast to the “scale beats noise” approach critiqued by Birhane et al. (2021) but would nevertheless require substantial amounts of carefully annotated and curated data. This is only possible with the consent and active participation of educators and students. Different educational scenarios may have diverse potential uses for GenAI, so it is necessary to develop applications tailored to different scenarios to enhance educational outcomes (Hogan, 2024).

Prompt Engineering Investigating prompt engineering and recognizing the nuanced nature of prompts are key to ensuring the quality of GenAI outputs: The design and

development of prompts for different purposes, tasks and inquiries are of paramount importance (Bozkurt, 2024b). Of equal relevance is fostering fine-tuning skills to enhance reliability and accuracy (Bozkurt & Sharma, 2023). The current generation of researchers and scientists working with GenAI have been trained in a world without it, and this perhaps makes them better able to assess the quality of outputs.

Addressing Concerns and Risks in GenAI-assisted Research

Exploring reliable ways GenAI can assist researchers is a worthwhile pursuit: One of the major roles GenAI can play in education is as a research assistant. Nonetheless, there are concerns and risks despite the many conveniences it can bring about (Cornell University Task Force, 2023; Kim et al., 2024). For example, should we reference GenAI as an academic source, and if so, when, and how do we do so appropriately when complex prompts are used? How can GenAI support the research process? To what extent should we acknowledge AI if sections of the original draft work are re-phrased in their entirety? What changes, if any, need to be made to metadata in abstracts when GenAI is used to assist in data extraction of research articles? There is no doubt that these questions need more systematic investigation.

Influence of Terminology On Perception and Use of GenAI

Paying attention to the language used to describe AI, including GenAI, should be a focus of future studies: Language “is a mode of action, one form in which people may act upon the world... as well as a mode of representation” (Fairclough, 1992, p. 63). What language or metaphor we use to describe GenAI may affect how we perceive this technology and how we use it. Popenici (2023) argues that “intelligence” is not an appropriate word, hence “too open to manipulations and playful misusing, allowing to cover a large variety of meanings that determine, with extraordinary power, its uses, and applications” (p. 9). This issue has captured researchers’ attention (e.g. Anderson, 2023; Gupta et al., 2024). For example, Dron (2023) and others question whether it is even accurate to describe it as artificial, inasmuch as an LLM is almost entirely composed of the products of human intelligence. Some researchers have already started “to deliberately distance themselves from the term ‘AI’ and revert to using labels that better describe the types of machine learning and algorithmic developments that underpin their work...such as ‘automated decision making’ and ‘algorithmic forecasting’” (Selwyn, 2024, p. 5). More research is needed in this direction.

Extending the Types of Research for a Deeper Understanding

This theme is made up of seven subthemes: theory-building of GenAI in education, interdisciplinary approach, applied and contextualized research, longitudinal impact research, comparative research, verification research and independent third-party research.

Theory-building of GenAI in education Emphasizing theory-building around GenAI in education will strengthen the academic foundation: We need to theorize GenAI through the lens of various learning theories and then test the resulting hypotheses. Much of our theoretical foundations come from other fields. We need to unpack core constructs of GenAI for education and theorize them so that we can test them (McGrath et al., 2024). We also need theoretical models and frameworks to make sense of the immense expansion of the *adjacent possible* that GenAI is bringing (Dron, 2023). Stracke et al., (2023, 2024a) that have proposed a standardized research protocol for both the use of AI in education as well as for education about AI (AI literacy) are good attempts in this direction.

Interdisciplinary Approach Adopting an interdisciplinary approach to research and theory can enrich future studies: Bringing together some combination of scholars with expertise in education, learning science, learning design, psychology and cognition, sociology, anthropology and/or computer science to discuss and collaboratively research influential dynamics between GenAI and learning more holistically would prove valuable and interesting. Different disciplinary approaches may compete but may also complement. After all, GenAI is an interdisciplinary domain (Chiu et al., 2023). Dron (2023) is a good example, which draws upon “complexity theory, the philosophy of technology and socio-technical systems, neuroscience, educational theory, and machine learning” (p. 320). More research needs to be conducted using an interdisciplinary approach.

Applied and Contextualized Research Conducting research at applied and contextualized levels will enhance practical understanding: Research should not be limited to GenAI itself or its technical aspects. Issues related to the use of GenAI should not be taken for granted. For example, can GenAI promote equity in education or reduce costs? Can it increase access to educational opportunities? In doing so, does the nature of the educational experience change for the better? How should it be used ethically or for the common good? There has been much abstract thinking, for example, about ethics and risks as well as the anticipation and development of tools and applications. The complexity of the technology and the limited understanding of its role

in education and society as well as how it might integrate within existing human practices all necessitate more contextualised studies (Sriprakash et al., 2024). For example, “prevailing notions of privacy, influenced by Global North perspectives, may not fully encapsulate the cultural and contextual nuances in Africa” (Prinsloo & Kaliisa, 2024, p. 1). Rodrigo (2024), who discusses the existing realities of education and educational research in the Philippines, offers poignant testimony to the need for applied and contextualized research.

Longitudinal Impact Research Including longitudinal impact studies will provide insights into long-term effects: Thus far, single case and short-duration intervention research dominates the landscape of GenAI (Mustafa et al., 2024; Yusuf et al., 2024). However, not all its impacts on education are immediate, not to mention that instant effects may not be reliable (Reeves & Lin, 2020; Xiao, 2023a). More longitudinal research, both quantitative and qualitative, and across cases is needed to investigate the long-term effects of GenAI on various aspects of education. For example, what are the long-term impacts on youth’s learning and cognitive development if GenAI use becomes more widespread? How can we research this safely without harming them? How does GenAI affect educational outcomes and career readiness in the long run? What are the long-term psychological effects of GenAI on students and teachers? What are its long-term effects on students’ autonomy in the learning process? How will GenAI redefine the goals of education? Does GenAI enrich or weaken humanity in education? The imperative of this kind of research cannot be overemphasized.

Comparative Research Conducting comparative studies allows for cross-contextual analysis and understanding: Whether GenAI is a tool or a disruptor of traditional education models, comparative studies across countries, levels of education, educational institutions and subjects/disciplines are instrumental lines of inquiry in ensuring appropriate uses of GenAI in education. For example, how is GenAI impacting education in a highly industrialized country versus a developing country? Are the technologies being used to democratize access to high-quality education, or are they perpetuating and reinforcing existing disparities? What about the use of GenAI in specialized fields such as medicine versus the arts? Could GenAI make medical training more efficient while simultaneously threatening the creative spontaneity of art education? Similar questions can be asked when it comes to different levels of education or different educational institutions. Comparative research like this can serve as a branch of applied and contextualized research.

Verification Research Focusing on what GenAI actually does to education, rather than what it can do, is crucial: It

is important to distinguish the current reality of the technological affordances from the rhetoric, hyperbole and hype cycle(s). While we need to explore the affordances of GenAI for education, it is more important to investigate what GenAI can actually do to education, both positively and negatively. Put simply, we need more replicable empirical studies to verify the claims made by GenAI proponents and enthusiasts (Altmeyer et al., 2024). We need to both stop presenting speculations as facts and find out whether they are possible or just all digital smoke and mirrors.

Independent Third-party Research Undertaking independent third-party studies will add objectivity and credibility to the findings: We have yet to see independent third-party research with the aim of verifying the effectiveness and affordances of GenAI for education. Given the magnitude of disruption that GenAI may bring about, any decision-making concerning the use of GenAI in education must be based on findings from independent third-party research (Altmeyer et al., 2024; Varsik & Vosberg, 2024). We need this type of research to find out whether GenAI is inevitable, necessary and good (Williamson et al., 2024).

Concluding Remarks

GenAI is probably here to stay. Nonetheless, it is imperative that we do not fall into the trap of fostering what Monett and Paquet (2024) refer to as “a collective massification of digital stupidity,” (p. 5) wherein GenAI becomes “a digital opium for the masses” (p. 6), masking the illusion of empowerment through unchecked technological adoption. The role of education communities is critical in that they must act as a counter-balance to the overwhelming hyperbole surrounding AI and its purported benefits in education (Selwyn, 2024). This study emerges from that need for critical reflection and responsible engagement with the evolving technology. For example, in an AI-enabled world, how can we prevent GenAI from aggravating the popular standardized/quantified assessment practices? How can we leverage this technology to resolve defects in the current assessment practices? How can we make sure that GenAI-mediated assessment contributes to the accomplishment of the desirable purposes of education? Indeed, GenAI in education has become a public problem (Williamson, 2024).

As demonstrated in the preceding sections, our inquiry yields questions that are rich and multifaceted, offering a wealth of insights into how GenAI is perceived by educators. These findings, although mainly focused on meso- and micro-level issues concerning learning, teaching and research, provide a solid foundation upon which future research can be built. The complexities surrounding GenAI in education extend far beyond classroom use, and this study

encourages further exploration of areas like cost-effectiveness, equitable access and environmental implications—issues that are underexplored here but crucial to broader debates.

It is also important to consider the identities of the participants, who are primarily educators, when interpreting these findings. Their concerns naturally gravitate towards the immediate impact of GenAI on pedagogy and academic practice. On the other hand, the findings indicate a critical need to broaden the discourse by incorporating the perspectives of policymakers, technologists and other stakeholders.

As a final remark, it is worth noting that while GenAI holds the promise of transformative potential, it is essential that we continue to approach it with caution, humility and critical inquiry. If left unchecked, the proliferation of GenAI in education could exacerbate inequalities, erode critical thinking and diminish the human element that is central to meaningful learning. Rather than blindly embracing AI as a panacea, we must remain vigilant, constantly asking ourselves not just what AI can do, but what it should do and what we, humans, can and should do as well. The real challenge facing us is not just harnessing the power of GenAI but ensuring that it serves the broader goals of education, equity and human and societal progress. If we fail to ask the right questions now, we may find that, in the pursuit of greater efficiency, we have lost the very essence of what it means to educate and learn.

Declarations

Competing Interests The authors have no competing interests to declare that are relevant to the content of this article.

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