

A Critical Analysis of GAI Learning Research: From Theory to Implementation Risks

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Abstract

While existing literature documents the benefits and concerns of Generative Artificial Intelligence (GAI) for learning processes, it largely overlooks fundamental learning theories such as Cognitive Load Theory, Constructivism, Activity Theory, and Bloom's Taxonomy. This study employs a scoping review methodology to identify current research gaps from the perspective of these theories, examining potential risks associated with uncritical GAI usage in learning environments. The results demonstrate that the current discourse focuses on operational aspects, while the learning fundamentals are largely overlooked. The identified risks include the bypassing of essential cognitive processing, fostering illusions of understanding, disrupting social and collective learning dynamics, compromising authentic motivation, and interfering with knowledge transfer and application. These risks manifest differently across various learner profiles, from K-12 students to professionals, with implications extending beyond individual learning outcomes to organizational effectiveness and information quality in broader societal contexts. The findings indicate the necessity for a structured, level-appropriate approach to GAI implementation in educational and professional settings. Future research should investigate long-term impacts of GAI on learning outcomes across different educational levels and diverse cultural and socioeconomic contexts, focusing on developing strategies that mitigate risks and support, rather than circumvent, essential learning processes identified by major learning theories. This research offers a theoretically grounded perspective that can inform more nuanced policy approaches to balance technological advancement with educational effectiveness across diverse global contexts.

Keywords: Generative artificial intelligence; Learning; Risks; Learning fundamentals

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Introduction

The growing influence of Generative Artificial Intelligence (GAI) across all sectors, including education, is occurring at a rapid pace. As is often the case with technological advancements, its growth and impact are outpacing our ability to fully comprehend its implications from fundamental perspectives in each field where it is being deployed (Crawford, 2021). This rapid integration aligns with global educational technology trends, with various international organizations taking distinct positions. UNESCO (2021) emphasizes AI-enhanced personalization, automation of routine tasks, and data-driven decision making. The OECD (2023) advocates for AI literacy and integration frameworks, while UNESCO's Recommendation on the Ethics of AI (2022) highlights the urgent need for research-informed approaches to AI implementation in learning contexts. Meanwhile, the European Commission's Digital Education Action Plan (2021-2027) focuses on the transformative potential of AI technologies in education.

Since November 2022, research on ChatGPT and GAI in education has increased exponentially, emphasizing the necessity for aligning AI with pedagogical principles. This includes considerations of learners' intrinsic motivation (Luckin & Cukurova, 2019; Dogan et al., 2023; Artemova, 2024), ethical use and academic integrity (Cacho, 2024), and support for self-directed learning (Li et al., 2024). However, research directions on GAI tend to overlook its alignment with fundamental learning principles described by Cognitive Load Theory (Sweller, 1988), Constructivism (Piaget, 1952; Vygotsky, 2012), Activity Theory (Leontiev, 1978; Engeström, 1987), and Bloom's taxonomy (Bloom et al., 1956)—theories that remain pertinent for understanding the complexities of human learning.

The aim of this study is to critically examine the intersection between GAI and fundamental learning theories by identifying research gaps in current literature and exploring potential risks of uncritical GAI implementation. This research has two primary objectives: first, to conduct a comprehensive scoping review that identifies how current research addresses essential learning principles across different learner profiles and second, to perform a contrasting analysis between GAI characteristics and established learning theories to identify how uncritical GAI usage might disrupt fundamental learning processes. The study seeks to establish a theoretical foundation for thoughtful GAI integration that preserves essential cognitive, social, and motivational aspects of learning.

Investigating the convergence of foundational learning theories with GAI is crucial to ensure these tools align with cognitive processes and facilitate meaningful learning while preventing excessive technology reliance and preserving learner autonomy. The following sections outline the theoretical background of learning theories, describe the scoping review methodology, present findings on learner profiles and GAI benefits and concerns, analyze contrasts between GAI and learning fundamentals, discuss theoretical gaps and risks, and conclude with empirical and theoretical implications.

Theoretical Background

A narrative review (Cumming et al., 2023) of the fundamental theories provides a comprehensive overview of foundations of human learning processes.

Cognitive Load Theory (Sweller, 1988) posits that human cognitive architecture has limited working memory capacity and that information presentation can either facilitate or impede learning. This theory emphasises designing instructional materials that minimise cognitive load on learners (Sweller, 1988). Long-term memory serves as the primary learning mechanism, enabling information integration into cognitive structures through schema formation (van Merriënboer & Sweller, 2005). Without long-term memory storage, learning would be impossible, as information would remain ephemeral (Kirschner et al., 2010). As Willingham (2021) emphasises, "Memory is the residue of thought," indicating that genuine learning occurs when information is processed deeply enough for long-term storage. Knowledge transfer, pattern recognition, and expertise development depend on this storage capacity (Anderson, 2000).

Schema formation in long-term memory reduces working memory burden (Sweller, 1988), enabling efficient processing of new information. This explains the contrasting approaches between experts and novices in problem solving. Experts possess well-developed memory for problem states, enabling rapid categorization based on experience and effective strategy deployment through sophisticated schemas. In contrast, novices rely on superficial structures and less effective methods, lacking the schemas necessary for efficient problem classification and resolution (Sweller, 1988).

The various currents of constructivism, exemplified by Piaget (1952) and Vygotsky (2012), have been re-examined in specific educational applications. Draganoudi et al. (2023) applied constructivist principles to analyze video game-based learning environments and their impact on knowledge construction, while Veresov & Veraksa (2022) examined how digital tools affect social interaction patterns in early childhood development. Piaget's theory aligns with Sweller's schema theory, providing complementary explanations of how schemas are constructed and modified through developmental stages (van Merriënboer & Sweller, 2005).

Learning occurs through assimilation and accommodation (Piaget, 1952). Assimilation involves incorporating new information into existing schemas (Piaget, 1976), while accommodation involves modifying cognitive structures to integrate new information (Piaget, 1970). These processes interact through "equilibration," driving cognitive development (Piaget, 1980; von Glasersfeld, 1995).

Vygotsky's sociocultural theory presents a comprehensive framework for understanding learning as fundamentally rooted in social interaction and cultural context. Vygotsky (2012) posits that learning is not merely an individual cognitive process; rather, it occurs initially on the social plane before being internalised by the individual. This process is mediated through cultural tools, particularly language, which serves as the primary tool for developing higher mental functions. This concept has been revisited by Leontjev & deBoer (2022) in the context of second language learning.

A fundamental concept in Vygotsky's theory is the Zone of Proximal Development (ZPD), which represents the distance between what learners can accomplish independently and what they can achieve with guidance from more knowledgeable others (Vygotsky, 2012). This concept emphasises that effective learning occurs when learners are challenged within their ZPD through the provision of appropriate scaffolding by skilled partners (Wood et al., 1976). The ZPD concept provides a framework for understanding how social interaction

drives cognitive development. It suggests that learners gradually internalise the support strategies provided by others, integrating these strategies into their own cognitive repertoire. One of the most recent examples of this concept being applied is in McCoy and Lynam (2022), who demonstrated how teachers develop their technology integration skills through guided interactions within their ZPD, utilising classroom contexts and digital tools to enhance their professional practice.

Furthermore, Vygotsky (1986) underscored the crucial role of language in cognitive development. He put forth the proposition that language initially serves as a conduit for social communication but subsequently becomes internalised as an internal monologue, thereby functioning as a tool for cognitive processes and self-regulation. This process of internalisation extends beyond language to encompass other cultural tools and practices, thereby illustrating how higher mental functions develop through social interaction within cultural contexts (Wertsch, 1988). Moreover, Vygotsky distinguished between scientific concepts, which are acquired through formal instruction, and everyday concepts, which develop through daily experience. These two types of concepts interact and influence each other, thereby contributing to the development of complex understanding through their integration.

Activity Theory, which has been developed over several generations from Leontiev (1978) to Engeström (1987, 2001), provides a framework for understanding learning as a complex, socially embedded process. The theory emphasises that learning cannot be considered in isolation from its broader social, cultural, and historical context. Instead, it is viewed as a dynamic system of interactions between the learner, tools, community, rules, and division of labour (Engeström, 1987).

Leontiev's (1978) foundational contribution was the development of a hierarchical model of activity, comprising three levels: activity (driven by motives), actions (guided by conscious goals), and operations (influenced by conditions). He highlighted that learning activities are driven by motives that may emerge through the process of exploration itself. This implies that the process of searching for information always precedes the definition of a specific learning subject matter, which is a crucial aspect of the learning process. This hierarchical structure elucidates the way learning activities evolve and transform through engagement with the environment. What initially manifests as a conscious action may subsequently become an automatic operation, and conversely, an operation may become a conscious action when conditions change (Leontiev, 1981).

Engeström (2001) developed expansive learning theory to explain how communities learn to perform new activities. This process is underpinned by several key principles, including multivoicedness (the presence of multiple perspectives within the activity system), historicity (an understanding of how practices evolve over time), contradictions (tensions that drive development), and expansive cycles (transformation through collective questioning and innovation). In accordance with this theoretical framework, learning is understood to occur through the interaction of these components and principles. This perspective emphasises that learning is not merely the acquisition of pre-existing knowledge; rather, it is a process of transforming activity systems through collective endeavour and the creation of new cultural tools (Engeström & Sannino, 2010).

Finally, Bloom's Taxonomy (Bloom et al., 1956), later revised by Anderson and

Krathwohl (2001), provides a hierarchical model of cognitive processes that are essential for learning. These processes are arranged in six levels, from lower to higher order thinking skills. The first level is remembering, which involves retrieving knowledge. The second level is understanding, which involves constructing meaning. The third level is applying, which involves using procedures. The fourth level is analysing, which involves determining relationships. The fifth level is evaluating, which involves making judgments. The sixth level is creating, which involves generating new patterns or structures. A re-examination of these theoretical foundations by Maani and Shanti (2023) revealed that the integration of video-based learning with Bloom's taxonomy results in a cost-effective and accessible learning environment.

Entry points into these cognitive levels vary by learner expertise (Krathwohl, 2002). While novices typically start at the “remember” level, experienced learners may enter at higher levels and engage multiple levels simultaneously, utilizing existing knowledge structures for higher-order thinking (Marzano & Kendall, 2006).

The taxonomy posits that meaningful learning necessitates engagement with progressively intricate cognitive processes, irrespective of the initial point of entry. Each level is constructed upon and integrated with those that precede it, thereby facilitating a more profound comprehension and a more nuanced mode of reasoning. This framework acknowledges that learning is a dynamic process, whereby prior knowledge facilitates higher-level entry points and learning can occur at multiple levels concurrently, contingent on the learner's domain expertise, familiarity with related concepts, and level of cognitive development (Anderson & Krathwohl, 2001).

This article acknowledges GAI's potential benefits in learning contexts, such as providing instant feedback (Lindsay et al., 2023) and enhancing analytical abilities through rapid processing of complex datasets (Ifenthaler & Schumacher, 2023). However, the present study focuses on identifying research gaps in how GAI implementation relates to fundamental learning principles across different learner profiles, and examining risks associated with uncritical GAI use. To achieve this aim, a scoping review addresses three key questions: Who are the learners being studied? What benefits are identified regarding GAI implementation across different profiles? What are the concerns? This approach reveals whether current research acknowledges essential learning processes such as schema development, social knowledge construction, and motivational dynamics. This systematic mapping, combined with a contrastive analysis between learning theories and current GAI research, identifies theoretical gaps in the literature. Building on these findings, the study then addresses potential risks of uncritical GAI implementation from a theoretical perspective. The following method section details this methodological framework.

Method

As a first step, a scoping literature review was conducted in social sciences using the SCOPUS database from November 2022 (ChatGPT's public release) to October 2024, including advance publications through December 2024. This review explored the range and nature of learner profiles, benefits, and concerns related to GAI in educational contexts (Casale et al., 2021).

Figure 1 illustrates the substantial growth in GAI education research during the review

period.

Figure 1

Publication Trends on GAI in Education: SCOPUS Database (January 2023-October 2024)

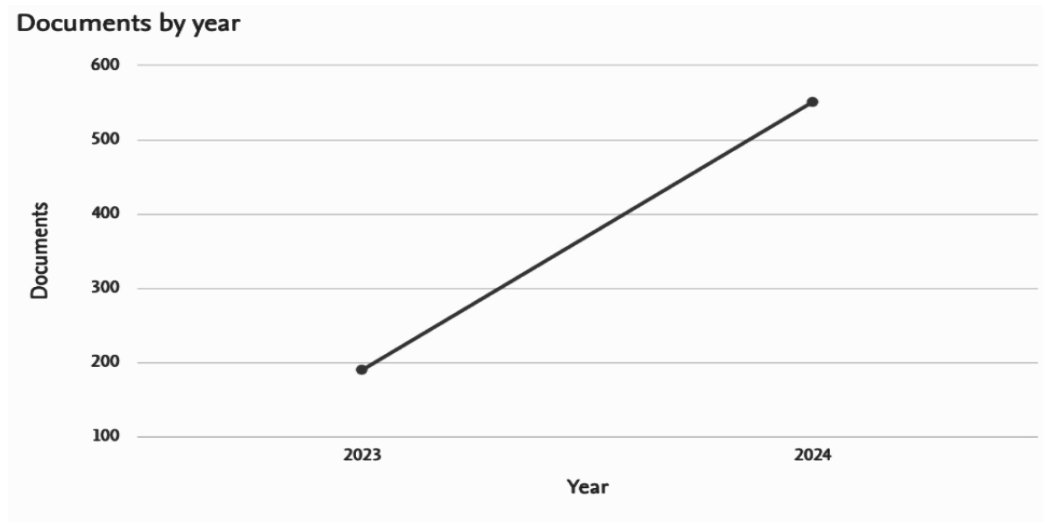
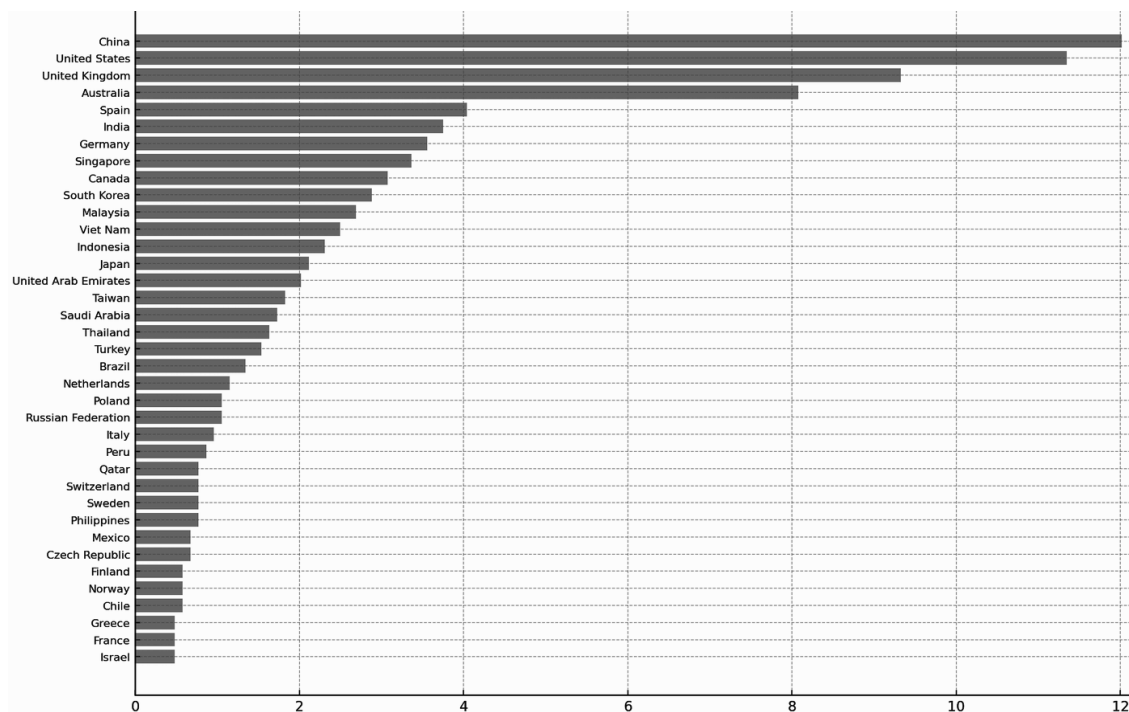


Figure 2 demonstrates the global interest in GAI education research.

Figure 2

Geographic Distribution of GAI in Education Research: Top 50% of Contributing Countries by Author Affiliation



Note. The figure shows the normalized percentage of publications from each country among the top 50% of contributors to GAI in education research (SCOPUS). Values reflect relative share, not raw counts—for example, China contributes just over 12% within this group.

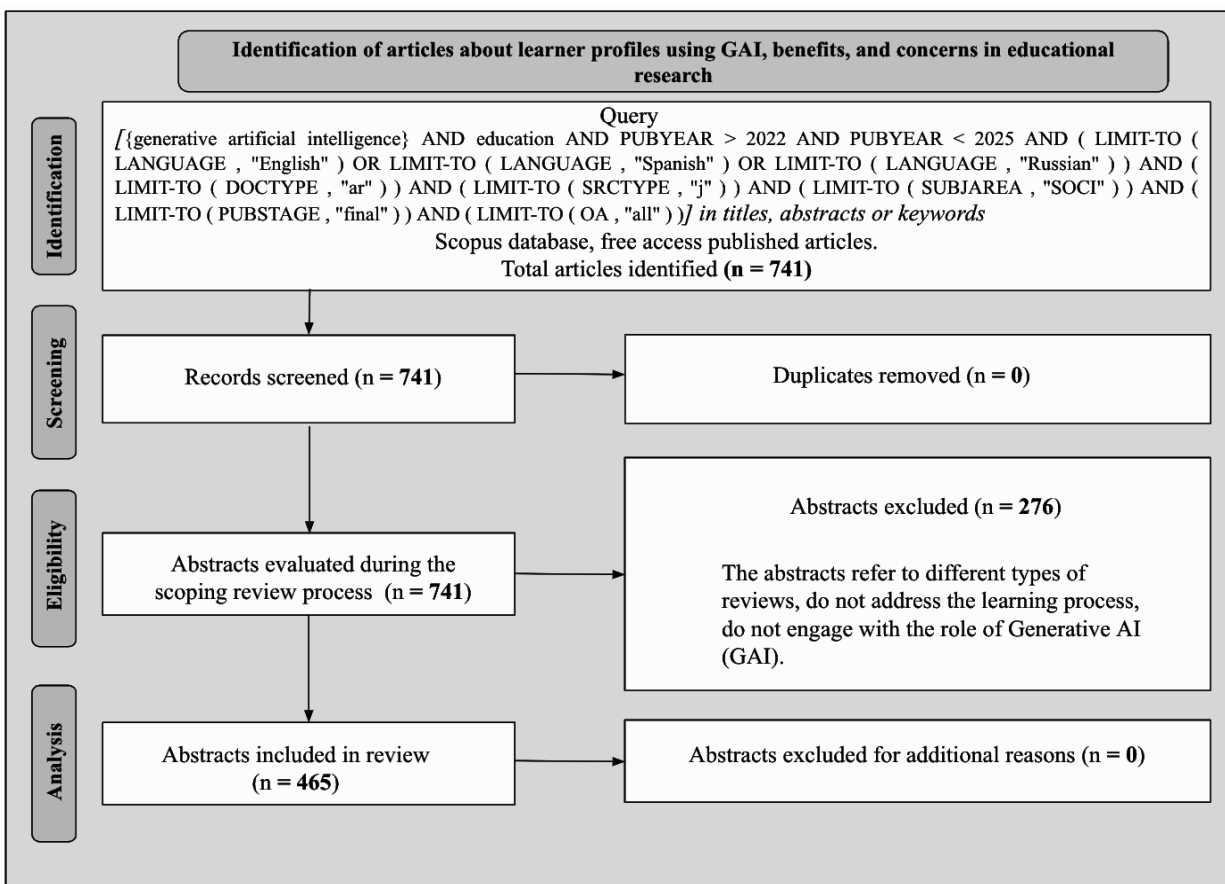
The scoping review methodology followed Arksey and O'Malley's (2005) framework:

- 1) Research questions were defined: What profiles of learners utilize GAI? What benefits regarding GAI in learning processes are identified in the literature? What are the concerns?
- 2) Identification of pertinent literature.

Figure 3 shows the flowchart outlining the steps of the literature search and analysis process.

Figure 3

Flowchart of the Literature Search and Analysis Process



A cross-disciplinary search for articles on GAI in education was conducted in the SCOPUS database using the following query: {generative artificial intelligence} AND education AND PUBYEAR > 2022 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , "Russian")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (SUBJAREA , "SOC")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (OA , "all")). For the scoping review, the broader term "education" was used to capture relevant research where learning processes might not be explicitly mentioned.

The search was limited to English, Spanish, and Russian (languages within the author's expertise) to ensure full-text readability when abstract information was insufficient. The search focused on social studies and was further refined to include only published articles, following the flexible approach permitted by scoping review methodology (Belt et al., 2022). This process identified 741 articles. The resulting dataset, including article titles and thematic categorizations, is openly available at Zenodo [<https://doi.org/10.5281/zenodo.15257517>].

3) Clear inclusion and exclusion criteria were defined to refine the sample. All types of literature reviews—systematic, scoping, and bibliographic—were excluded. Two main inclusion criteria required abstracts to address the learning process and GAI. Although GAI was part of the search query, not all retrieved studies focused on it as an object of study. This filtering narrowed the corpus to 465 abstracts, spanning various educational levels and disciplines, in line with the study's focus.

4) Recording of the results across sources. This stage was conducted using Microsoft Excel, where data were recorded according to three analytical categories: a) the profile of learners using GAI, b) the reported benefits of its use, and c) concerns identified in the literature regarding GAI in the learning process.

Steps three and four were supported by ChatGPT, especially in step three, where it enabled a more efficient and accurate evaluation of a large initial sample of abstracts (Miranda et al., 2023). Each abstract was evaluated based on three questions: 1) Does it report any type of review (systematic, scoping, or bibliographic)? 2) Does it address the learning process? 3) Does it involve GAI? ChatGPT generated Yes/No responses for each question and the results were reviewed and validated by the author, resulting in a final dataset of 465 abstracts.

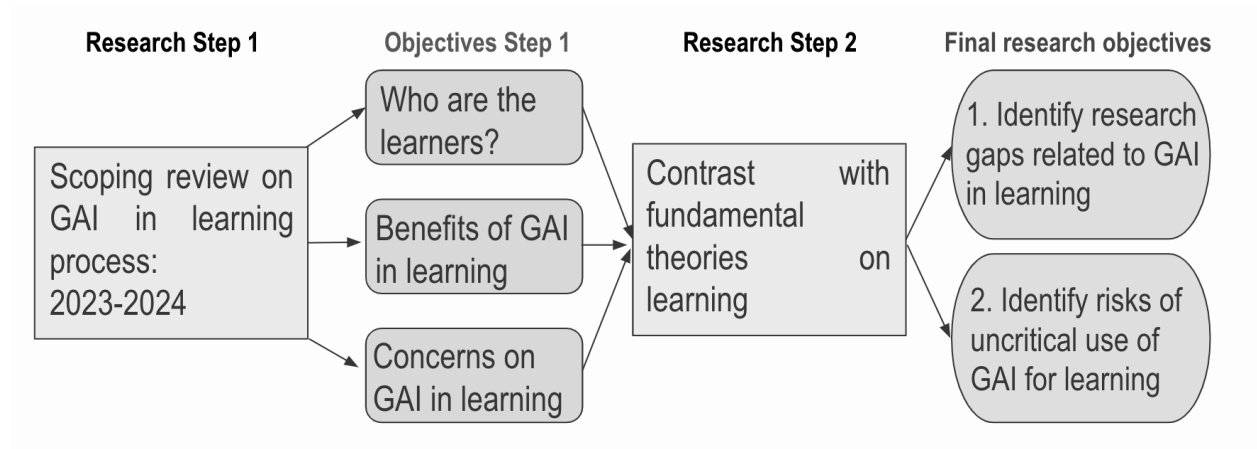
The process drew on insights from Cardoso Sampaio et al. (2024), whose research examined the benefits and limitations of GAI in scoping reviews. In line with this, GAI was initially used to apply exclusion criteria, while the author thoroughly evaluated the remaining abstracts in step four.

The selected abstracts were analysed with ChatGPT, organized around three analytical categories: 1) learner profiles—identifying who uses GAI in learning, 2) benefits—advantages linked to its use, and 3) concerns—issues raised by researchers. Although most abstracts followed a structured format, the author carefully reviewed all generated responses. ChatGPT notably reduced the time required for organizing and drafting responses, and the results are summarized in the accompanying Excel database.5) Summarizing the findings. The final stage is outlined in the Results section.

Figure 4 illustrates the methodological approach employed in the present study.

Figure 4

Methodological Workflow: Analysis of GAI Learning Research Gaps and Associated Risks



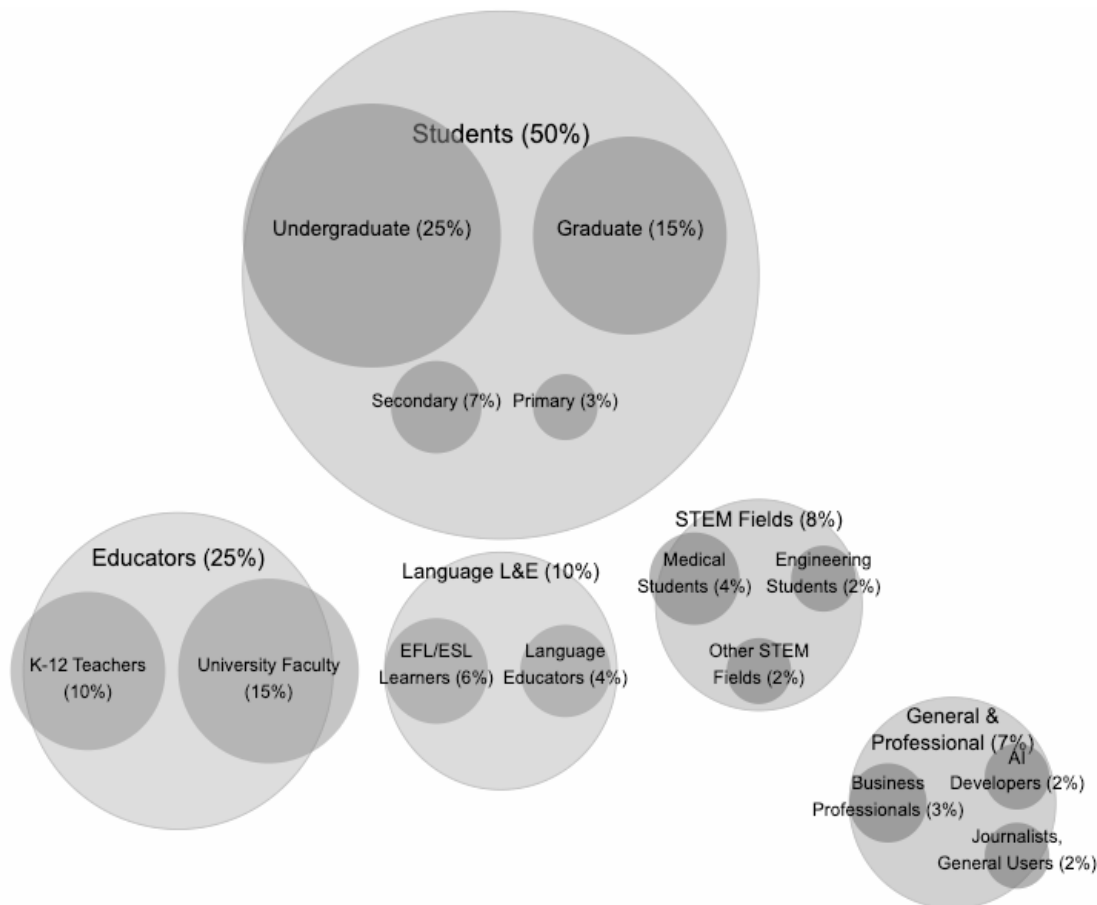
Results

Scoping Review

The findings of the scoping review are presented in Figure 5.

Figure 5

The Learners Profile of the Users of GAI for Learning Purposes.



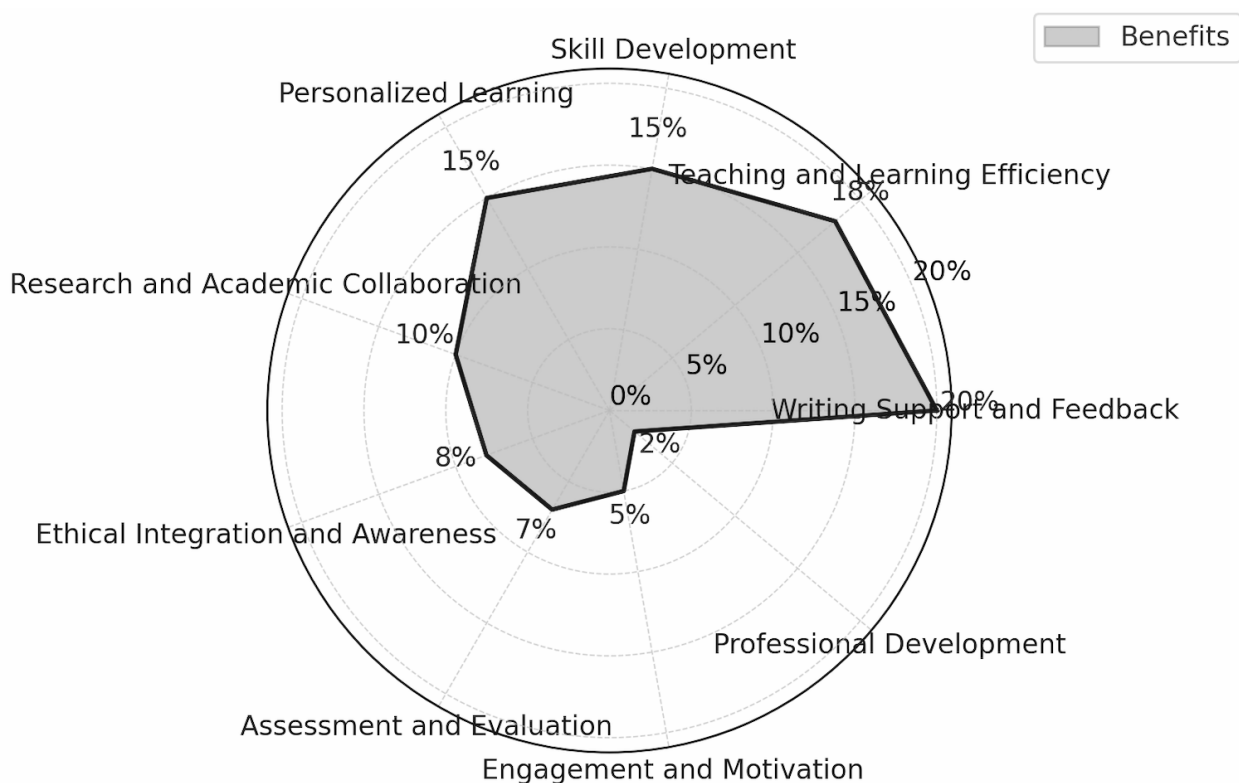
The results indicate that students represent the largest segment of users, comprising 50% of the total. Undergraduate and graduate students are the most active users of AI, employing it for research, essay writing, and project support. Educators, representing 25% of users, employ GAI for curriculum design, lesson planning, and academic research. K-12 teachers (10%) and university faculty (15%) are among those who recognise its potential to enhance teaching practices. A further 10% of users are language learners and educators who employ GAI for language acquisition, translation, and the creation of interactive materials, particularly among those learning English as a foreign language or as a second language (6%). In the field of STEM, 8% of users explore AI for specialised learning and technical tasks while 4% of medical students and 2% of engineering students do the same. It is noteworthy that, although the research was conducted in the field of education, other types of users were also identified. These include general and professional users (7%) who include AI developers (2%), business professionals (3%), and journalists (2%), who rely on GAI for content creation and data analysis.

What Are the Corresponding Benefits?

Figure 6 represents the results on benefits that the researchers find for the learners.

Figure 6

The Benefits of GAI for Learners



As evidenced by the results, the integration of GAI in an educational context offers a range of benefits to its users. Among these, the provision of writing support and feedback accounts for 20% of the reported advantages. The utilisation of GAI serves to enhance the competencies associated with the written expression of ideas, facilitating improvements in grammatical correctness, organisational proficiency, and stylistic elegance. Furthermore, the provision of personalised feedback serves to mitigate the anxieties commonly experienced by learners and to facilitate effective revision. The automation of routine tasks, such as grading and content creation, enables educators to streamline processes and provide more personalised instruction, thus enhancing the efficiency of teaching and learning (18%).

GAI fosters both skill development and personalised learning (15% each). Furthermore, users benefit from improved research and academic collaboration (10%) which facilitates the discovery of resources and the synthesis of knowledge. Other advantages include the promotion of ethical integration and awareness (8%), the enhancement of assessment and evaluation (7%)

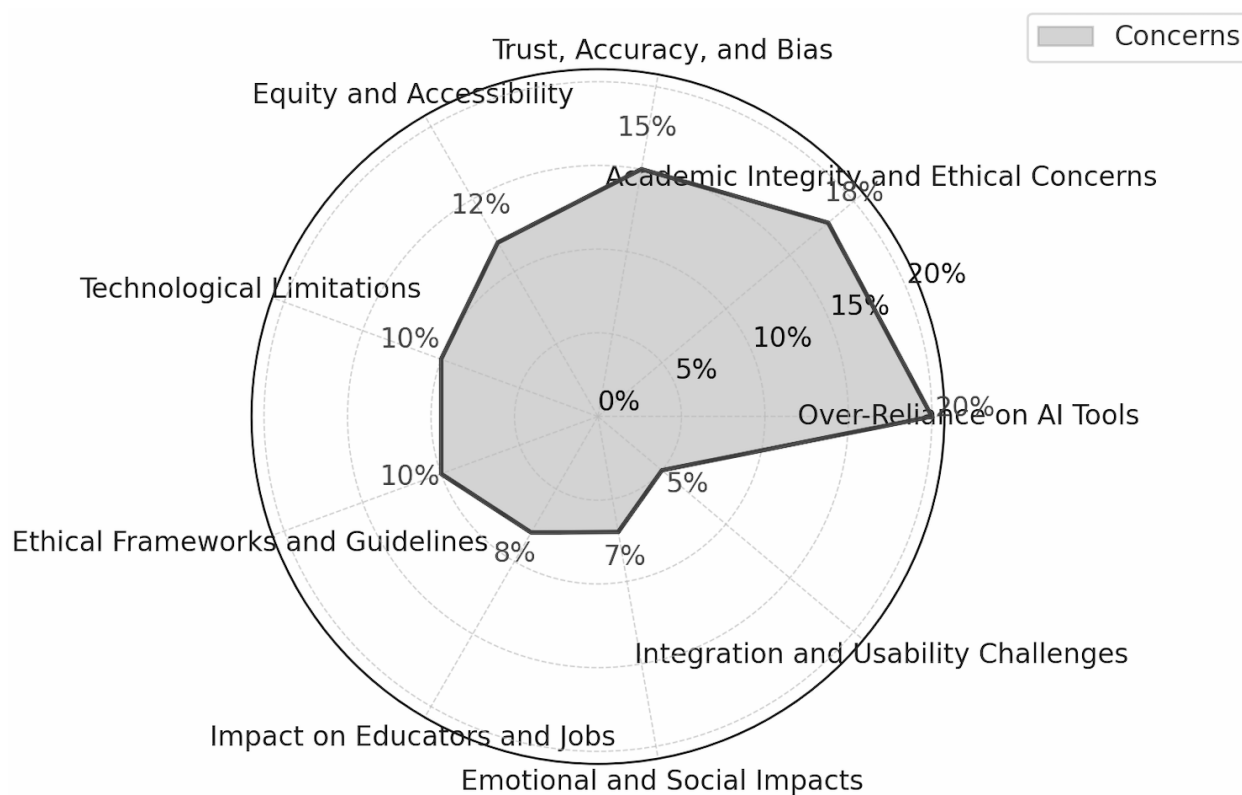
through automation, and the encouragement of engagement and motivation (5%). Although professional development accounts for a minor proportion (2%), it plays an invaluable role in equipping educators with the knowledge and skills required to integrate AI effectively into their teaching practice.

What Concerns Have Been Identified in the Research Literature with Regard to the Utilisation of GAI in the Learning Process?

Figure 7 illustrates the types of concerns that have been identified in the research literature regarding the utilisation of GAI in the learning process.

Figure 7

The Concerns Around the Use of GAI for Learners.



The utilisation of GAI in the learning process gives rise to several queries, with the most pressing being the over-reliance on AI tools (20%). A reliance on AI may impede the development of critical thinking, creativity, and self-regulated learning by redirecting attention from manual problem-solving to automated solutions. Such an over-reliance carries the risk of replacing essential human interaction in education. Furthermore, academic integrity and ethical concerns (18%) are significant issues, with potential risks of plagiarism, cheating, and ethical challenges regarding equitable access and privacy. Furthermore, issues pertaining to the reliability of AI, the fabrication of references, and the potential perpetuation of stereotypes through biased models have been identified (15%). The challenge of ensuring equity and

accessibility (12%) highlights the disparity in access to AI tools across socioeconomic and geographical boundaries, which can exacerbate existing inequalities.

Other concerns include the technological limitations of AI. Specifically, its capacity for handling nuanced reasoning and ensuring consistency (10%) and its lack of ethical frameworks and guidelines for responsible AI integration (10%) leave educators without clear standards for such integration. The potential impact on educators and employment (8%) contributes to concerns about job displacement and resistance to transformative technologies. Furthermore, the potential for reduced collaboration, emotional detachment, and waning enthusiasm for traditional learning methods is indicated by the emotional and social impacts (7%), which also highlight the possibility of adverse effects on the social and emotional well-being of learners. Finally, the integration and usability challenges (5%) indicate obstacles to institutional preparedness, training, and AI literacy for both students and educators. These concerns collectively underscore the necessity for a prudent, equitable, and rigorously regulated integration of GAI in educational settings.

After analysing the learning profiles, benefits, and concerns surrounding GAI implementation in the learning process, the study now proceeds to a contrasting analysis. By comparing GAI characteristics with the fundamentals of human learning processes, this analysis identifies how uncritical GAI usage may potentially disrupt essential learning mechanisms across different contexts.

Contrasting Analysis

The use of NLP by GAI models such as ChatGPT enables them to understand and generate human language, thereby facilitating engagement in natural conversations and the production of coherent text across various genres (Liao et al., 2023). The models are pre-trained on extensive datasets and fine-tuned for specific tasks, thereby enabling them to generate high-quality content (Jin, 2023). Furthermore, these models can adapt to diverse learning contexts and providing personalised educational experiences, thus enhancing the learning process for students (Liu et al., 2023). Additionally, these models are designed to process and respond to inputs almost instantaneously, ensuring that learners receive immediate feedback or information.

Despite their pedagogical potential, GAI models often conflict with established cognitive learning principles, particularly in how they manage information processing and schema construction.

The uncritical application of GAI in learning contexts gives rise to significant contradictions with Sweller's Cognitive Load Theory, particularly regarding the way the human cognitive architecture processes and stores information for meaningful learning.

The principal contradiction arises from the impact of GAI utilisation on the management of working memory and the construction of schemas. While Sweller (1988) emphasises that learning requires careful management of cognitive load to facilitate the transfer of information from working memory to long-term memory, GAI often provides excessive information without consideration for cognitive processing limitations. This can result in an overload of information

for working memory, particularly in novice learners who have not yet developed the capacity to process complex information efficiently. While Willingham notes that "memory is the residue of thought" (Willingham 2021: 41), GAI-generated content often circumvents the essential deep processing that creates this residue.

Moreover, the utilisation of GAI has the potential to impede the organic evolution of expertise. When learners rely on GAI to provide immediate solutions, they circumvent the essential process of schema construction and refinement. This is a particularly problematic issue, as van Merriënboer and Sweller (2005) elucidate, as meaningful learning necessitates the gradual construction and modification of schemas in long-term memory. The provision of ready-made solutions by GAI may create the impression of understanding, while failing to support the cognitive processes necessary for the development of genuine expertise.

Additionally, the utilisation of GAI can impede the transfer of learning, which Cognitive Load Theory identifies as a pivotal aspect for the development of expertise. As Anderson (2000) posits, effective learning facilitates the transfer of knowledge across contexts and the recognition of patterns in novel situations. However, should learners depend on GAI for solutions without engaging in the requisite cognitive processing, they may fail to develop the robust schemas that facilitate such transfer. This can result in a superficial understanding that is unable to support the application of knowledge in novel situations, which is contrary to the fundamental goal of building expertise through schema development (Kirschner et al., 2010).

The indiscriminate application of GAI in educational contexts is fundamentally at odds with Piaget's tenets of cognitive development, as evidenced by several significant discrepancies. In accordance with Piaget's theory (1952), learning is achieved through active engagement with information and experiences, resulting in the construction of knowledge through the processes of assimilation, accommodation, and equilibration. However, should learners rely primarily on GAI, they run the risk of bypassing these essential cognitive processes.

The fundamental contradiction arises from the fact that GAI can substitute active knowledge construction with passive information reception. While Piaget emphasises that meaningful learning requires learners to grapple with concepts, identify inconsistencies, and construct understanding personally (von Glasersfeld, 1995), GAI provides immediate, ready-made answers. This circumvents the crucial cognitive conflict that Piaget identified as necessary for development (Piaget, 1976). To illustrate, when students employ GAI to devise solutions without undergoing the problem-solving process, they bypass the indispensable phase of schema modification and cognitive restructuring that occurs during genuine accommodation.

Furthermore, the utilisation of GAI can impede the natural equilibrium process by furnishing data that has not been adequately integrated into the existing cognitive structures. As Piaget (1980) observed, cognitive development necessitates a harmonious interplay between assimilation (the incorporation of novel information into extant schemas) and accommodation (the modification of schemas to align with new information). The assimilation of GAI-generated content without a connection to the learner's personal experiences or existing knowledge structures carries the risk of developing a fragmented understanding rather than integrated, meaningful learning (Wadsworth, 2003). This is a particularly problematic

phenomenon, as it can create an illusion of understanding without the deep cognitive processing that is essential for genuine learning and development.

The indiscriminate application of GAI in the context of learning processes gives rise to several inconsistencies when viewed through the lens of Vygotsky's sociocultural theory of learning and development. The primary contradiction can be found in social interaction and mediation. While Vygotsky (2012) posits that learning occurs initially on the social plane through interaction with more knowledgeable others, GAI provides information without the genuine social interaction that characterises human learning. This circumvents the indispensable process of social meaning-making and the gradual internalisation of knowledge through dialogue and shared understanding. When learners primarily utilise GAI, they fail to consider the nuanced social cues, emotional responses, and cultural context that Vygotsky (1988) identified as pivotal for cognitive development.

Moreover, the utilisation of GAI has the potential to impede the optimal functioning of the ZPD. While Vygotsky's theory emphasises the importance of carefully calibrated scaffolding provided by skilled partners who can assess and respond to a learner's current understanding (Wood et al., 1976), GAI typically provides standardised responses that may not accurately target a learner's ZPD. This can result in either an overwhelming influx of information that exceeds the learner's current capabilities or a lack of sufficient challenge. The dynamic and responsive nature of human scaffolding, which allows for gradual adjustments to align with the learner's evolving understanding, is challenging to replicate through GAI interactions.

The development of language and thought, which Vygotsky (1986) identified as intimately connected through the process of internalisation, may also be adversely affected. Although GAI can provide language input, it is unable to facilitate the kind of meaningful dialogue essential for the development of inner speech and self-regulation. The absence of authentic social interaction and cultural context in GAI-mediated learning may impede the development of higher mental functions that Vygotsky identified as emerging through social interaction and cultural mediation.

The indiscriminate deployment of GAI in learning contexts gives rise to considerable tensions with Activity Theory as articulated by Leontiev and Engeström, particularly about its impact on the intricate dynamics of socially embedded learning processes.

From the perspective of hierarchical activity structure as developed by Leontiev (1978), the usage of GAI can disrupt the natural emergence and development of learning motives. While Activity Theory posits that a learning path commences and is directed by the motive, in the process of searching for a subject matter that aligns with a learner's interests, GAI's immediate responses circumvent this pivotal process of motive formation, objectives, and subject matter identification. This may impede learners from developing authentic motivational engagement with the subject matter and hinder the natural transformation of conscious actions into automated operations through practice and experience (Leontiev, 1981).

In accordance with Engeström's (2001) expansive learning theory, the utilisation of GAI has the potential to significantly contravene several pivotal principles. The principle of multivoicedness is undermined when GAI replaces the diverse perspectives and contradictions that naturally arise in community interaction with standardised responses. Similarly, the historical development of practices (historicity) may be overlooked when GAI provides decontextualised solutions that fail to account for the evolution of knowledge and practices over time. Most significantly, GAI may impede the constructive contradictions that Engeström identifies as vital drivers of development and change. Rather than engaging learners in grappling with contradictions, it tends to offer definitive solutions (Engeström & Sannino, 2010).

Moreover, the utilisation of GAI can impede the collective nature of knowledge creation, which is a pivotal aspect of Activity Theory. While the theory emphasises learning as a transformation of activity systems through collective effort and the creation of new cultural tools, GAI might promote individual, isolated interaction that bypasses the essential collective processes of questioning existing practices, analysing contradictions, and developing new solutions through community engagement (Engeström, 1987).

The indiscriminate application of GAI in educational contexts gives rise to considerable inconsistencies regarding Bloom's Taxonomy of cognitive development and learning processes.

The principal contradiction arises from the way GAI utilisation can impede the natural progression through the cognitive levels. While Bloom's Taxonomy emphasises the importance of building from foundational knowledge through increasingly complex cognitive processes (Bloom et al., 1956), GAI provides immediate high-level responses that bypass essential lower-level cognitive development. This is particularly problematic for novice learners, who require the establishment of a robust foundation of understanding before engaging with more complex cognitive tasks. When students employ GAI to generate analyses or evaluations without first developing their own understanding, they bypass the essential processes of knowledge construction and comprehension (Anderson & Krathwohl, 2001).

Moreover, the utilisation of GAI can impede the genuine advancement of higher-order thinking abilities. Although the taxonomy posits that the generation of new ideas and the evaluation of existing ones should emerge from a profound comprehension of the subject matter (Krathwohl, 2002), GAI can facilitate the production of sophisticated outputs without necessitating the learner's engagement in authentic analytical or evaluative thinking. This is a significant issue because it can create the impression of proficiency at higher cognitive levels without the underlying development of essential thinking skills. To illustrate, when students employ GAI to generate creative or evaluative content, they may circumvent the indispensable processes of analysing the relationships between concepts, evaluating evidence, and synthesising novel ideas derived from their own understanding (Marzano & Kendall, 2006).

Discussion

The research identified several key findings regarding concerns related to the use of GAI in the learning process, as well as the potential risks associated with its uncritical

application in learning.

Theoretical Gaps in GAI Learning Research: Beyond Operational Concerns

The scoping review revealed a significant gap between current research focus and core principles of learning. Most studies emphasize operational concerns—such as over-reliance on AI tools (20%), academic integrity (18%), and accuracy issues (15%)—while largely neglecting deeper pedagogical implications.

Reported benefits are similarly framed around practical advantages like writing support (20%), teaching efficiency (18%), and skill development (15%), rather than addressing how GAI aligns with or disrupts fundamental learning processes.

This gap becomes more evident when viewed through established learning theories. Cognitive frameworks such as Piaget's developmental model and Cognitive Load Theory stress natural knowledge construction and schema development—areas scarcely addressed in current GAI literature. Although some studies acknowledge social aspects (7%) or collaboration benefits (10%), they rarely explore how GAI may disrupt authentic social learning or cultural meaning-making, as emphasized by Vygotsky. Likewise, while engagement (5%) and personalized learning (15%) are often cited, research fails to critically assess the impact on cognitive progression and motivation formation, central to Activity Theory and Bloom's Taxonomy.

These theoretical oversights are particularly relevant when considering learner profiles. For novice learners (K–12), uncritical use may hinder the formation of foundational cognitive structures. Among undergraduates and graduates (50% of users), reliance on GAI without theoretical grounding may limit deep cognitive engagement necessary for expertise development. For educators in the role of learners (25%), weak integration strategies risk undermining the quality of learning and reinforcing questionable behaviour patterns. The findings highlight the need to expand research beyond operational themes to critically examine how GAI shapes, supports, or disrupts the mechanisms of human learning and development. Without this shift, the risks of uncritical adoption in educational contexts may outweigh the benefits.

Risk of Bypassing Essential Cognitive Processing

When learners employ GAI without adequate pedagogical direction, they frequently bypass fundamental cognitive processes emphasized by major learning theories. Sweller's Cognitive Load Theory emphasises the importance of deep processing for schema construction, while Piaget's theory highlights active knowledge construction, and Bloom's taxonomy stresses the necessity of sequential cognitive development (Sweller, 1988; Piaget, 1952; Bloom et al., 1956). To illustrate, a first-year student engaged in the composition of a literature analysis may utilise GAI to generate sophisticated interpretations without first developing an understanding of the text's fundamental themes and structure.

The circumvention of essential cognitive processing is particularly problematic for novice learners encountering new subjects, as they are less equipped to navigate the complexities of such unfamiliar terrain. Consider the case of a high school student learning

calculus who employs GAI to solve complex problems without first acquiring a fundamental understanding of the underlying concepts. Although they may achieve the correct answers, they fail to engage in the essential process of developing mathematical schemas and problem-solving strategies, which Sweller identifies as crucial for genuine learning and subsequent application (van Merriënboer & Sweller, 2005).

To mitigate this risk, educators can implement a structured approach requiring students to demonstrate their cognitive processing before using GAI. For example, a calculus instructor might require students to first manually solve simpler versions of problems, explaining their reasoning in writing, before allowing GAI verification of complex calculations. Similarly, literature professors could mandate initial self-generated interpretations of texts, with GAI used only to compare against the student's established analysis. This scaffolding preserves schema development and frames GAI as a support tool.

In online education, where restricting access to generative AI is challenging, instructors can promote authentic engagement by requiring voice or video reflections and personal process explanations (e.g., “What did you struggle with most?”). These formats are more difficult to delegate to AI and foster deeper student engagement with the learning material. However, the objectives for such practices must be set thoughtfully, aimed at enhancing the cognitive processes that support learning, rather than solely focused on deterring students from using generative AI.

Risk of Illusion of Understanding

Learning theories show how GAI can create a false sense of understanding without genuine comprehension. Sweller’s expertise development, Piaget’s equilibration, and Bloom’s hierarchy all stress the need for progressive cognitive engagement (van Merriënboer & Sweller, 2005; Wadsworth, 2003; Krathwohl, 2002). For example, a computer science student might use GAI to produce intricate code without grasping core programming principles—an illusion exposed when debugging or modifying code independently.

This misperception of comprehension is especially problematic in advanced academic contexts. It is possible that graduate students may utilise GAI to construct sophisticated academic arguments without developing the requisite deep analytical skills for genuine scholarly work. The theories collectively indicate that this circumvention of genuine cognitive engagement hinders the formation of robust mental models and schemas, which are essential for true expertise development.

To counter this, educators can use assessments that test real comprehension. Coding instructors might allow GAI use but require students to fix errors or adapt code independently. Research mentors can ask students to explain methodology choices verbally, without relying on AI. These strategies ensure GAI supports rather than replaces learning.

In online contexts, such methods are essential. Video explanations, oral defenses, and reflective prompts help reveal genuine thinking. Tools like tablets and styluses also encourage handwritten work on platforms like Moodle, showcasing process-based thinking in various subjects like math, design, or journaling—keeping GAI as a scaffold, not a shortcut.

Risk of Disrupting Social and Collective Learning

Multiple learning theories highlight the risk that GAI may inadvertently isolate learners from essential social learning. Vygotsky's sociocultural theory, Leontiev and Engeström's Activity Theory, and aspects of Piaget's work emphasize the central role of interaction in cognitive development (Vygotsky, 2012; Engeström, 2001; Wertsch, 1988). For example, undergraduate students in a group project might use GAI individually, missing the cognitive benefits of discussion, negotiation, and collective problem-solving.

This concern is especially relevant in language learning and early education. A language student relying on GAI for translation and writing may bypass the social exchanges Vygotsky deemed critical for acquiring both native and foreign languages. Such isolation can hinder the development of communication skills, cultural understanding, and collaborative reasoning.

To protect these dynamics, educators can redesign group tasks to integrate GAI while emphasizing interpersonal interaction. For instance, language instructors might ask students to co-create original content, then evaluate GAI suggestions together, focusing on cultural nuances the AI overlooks. Likewise, project-based learning can feature "AI-free" brainstorming sessions, followed by collaborative critique of AI-generated outputs.

Risk of Compromising Authentic Motivation and Exploration

Learning theories converge on the importance of natural curiosity and motivation in the learning process. The concept of motive formation as proposed by Leontiev (1978), Piaget's (1976) emphasis on discovery learning and Vygotsky's (1976) idea of scaffolded exploration all emphasise the importance of genuine learning emerging from authentic engagement with challenges. A science student who immediately turns to GAI for experimental design may fail to appreciate the value of the process of hypothesis formation, trial and error, and the natural development of scientific curiosity that arises from grappling with research questions.

The impact on motivation is particularly evident in project-based learning scenarios. When students rely on GAI to provide immediate solutions or creative ideas, they fail to engage in the essential process of developing intrinsic motivation through exploration and discovery. To illustrate, an art student utilising GAI to devise design concepts may fail to gain the invaluable experience of developing their artistic identity through experimentation and personal expression.

To safeguard intrinsic motivation, educators can establish clear boundaries for GAI usage that preserve exploratory learning. For example, science teachers might restrict GAI access during initial hypothesis formation and experimental design, allowing its use only after students have developed their own approaches. Art instructors could implement a rule where GAI is used only after students have generated multiple original concepts, positioning it as a creative dialogue partner rather than an idea generator. These strategies maintain the essential motivational benefits of struggle and discovery while introducing GAI as a reflective tool that extends rather than replaces authentic exploration.

Risk of Interfering with Knowledge Transfer and Application

The theories collectively emphasise that the utilisation of GAI can impede the development of transferable knowledge and skills. The emphasis placed by Sweller on schema development, the focus of Bloom on higher-order thinking skills, and the concept of internalisation proposed by Vygotsky all indicate the significance of developing flexible and applicable understanding (Anderson, 2000; Krathwohl, 2002; Engeström & Sannino, 2010). A business student who relies on GAI for case study analyses may develop a knowledge base that is compartmentalised and does not readily transfer to real-world business situations, where problems are less structured and require flexible thinking.

Such interference can be particularly problematic in the context of professional education. For example, medical students who rely extensively on GAI for diagnostic reasoning may encounter difficulties in developing the robust clinical reasoning schemas that are essential for addressing complex and ambiguous cases in actual practice. The aforementioned theories posit that such reliance on GAI can impede the development of the comprehensive, interlinked knowledge structures that facilitate effective knowledge transfer and utilisation in novel contexts.

The societal implications of these knowledge transfer limitations extend beyond individual learning outcomes. By systematically bypassing essential cognitive processes in favor of efficiency, educational institutions risk developing generations with superficial knowledge structures who struggle with novel problem-solving in evolving contexts. This could ultimately affect workforce readiness and innovation capacity in fields requiring adaptable expertise and creative problem-solving abilities.

Educators can enhance knowledge transfer by designing authentic application scenarios that strategically limit GAI involvement. For instance, business educators might allow GAI for initial case analysis but require students to independently apply findings to novel, ambiguous scenarios without AI assistance. Medical educators could implement simulated diagnostic exercises where students first develop their own clinical reasoning before comparing their approach with GAI-generated differentials. This staged approach ensures students develop the flexible mental models necessary for knowledge transfer.

Risks of the Integration of GAI in Learning Contexts Across Different Profiles

The learning risks associated with GAI vary significantly across educational levels, requiring tailored mitigation strategies. According to the scoping review, 50% of users are students across academic levels, but use also extends to professionals and educators. Each group presents distinct challenges in integrating GAI while safeguarding essential learning processes.

At the secondary level, the focus should be on developing foundational cognitive and social competencies. Manual problem-solving and peer interaction are essential. GAI should be introduced gradually, primarily as a verification tool after independent work, to encourage research skills and autonomous thinking.

In high school, the emphasis shifts to analytical and critical thinking. Students can begin comparing their work with GAI outputs to verify ideas rather than rely on the tool

outright. Group discussions before using GAI help strengthen collaboration and independent reasoning, positioning AI as a support, not a crutch. This approach facilitates students' comprehension of AI as a supplementary instrument while sustaining their cognitive growth.

In higher education, the focus shifts towards the attainment of more sophisticated learning objectives. It is recommended that students utilise the GAI tool primarily for the refinement of pre-existing ideas and the verification of understanding through peer discussion. It is recommended that students be encouraged to apply concepts independently before seeking assistance from GAI, thus fostering the development of original thinking. This approach may assist in maintaining the integrity of higher education's objective of fostering the development of independent, critical thinking skills.

At the graduate level, GAI should be regarded as a supplementary tool, with the primary emphasis placed on original research and analysis. It is recommended that students at this level maintain robust peer collaborations and prioritise the development of practical application skills before integrating GAI assistance. This guarantees that advanced academic work remains rigorous and contributes to the development of genuine expertise in the field.

For the users beyond educational settings, such as general and professional users, including business professionals, AI developers, and journalists, who also employ GAI for learning purposes, the risks of uncritical GAI usage similarly manifest but with broader immediate societal implications. Business professionals without understanding the risks of uncritical GAI use may develop decision-making approaches that lack the robust mental models necessary for complex business environments. Journalists relying on GAI without critical engagement risk contributing to information ecosystems characterized by superficial analysis. Most concerning, AI developers who do not recognize these learning risks may inadvertently design systems that perpetuate these same limitations at scale.

These professional contexts illustrate how the theoretical gaps identified in GAI research extend beyond individual learning outcomes to impact organizational effectiveness, information quality, and the design of future technological systems that shape societal knowledge construction. A progressive approach to GAI integration across educational and professional contexts is therefore essential to protect fundamental learning processes while enabling appropriate technology use at each developmental stage. Addressing these theoretical considerations requires a fundamental reorientation toward frameworks grounded in established principles of human learning, necessitating collaboration between learning scientists, educational practitioners, and AI developers to ensure that GAI enhances rather than circumvents the cognitive, social, and motivational processes essential for genuine learning and expertise development.

To mitigate this risk, educational institutions can establish developmentally appropriate guidelines that evolve with learner expertise. For example, secondary schools might adopt an approach where students first complete assignments on their own and then use GAI to review their work and identify areas for improvement. Universities could develop discipline-specific frameworks that progressively increase GAI access as students demonstrate fundamental competencies. Professional learning environments can establish critical evaluation protocols requiring practitioners to document their reasoning before consulting GAI. These tiered approaches ensure that GAI integration aligns with learning

fundamentals across diverse contexts while recognizing the varying needs of different learner profiles.

Conclusion

The analysis of key learning theories—Cognitive Load Theory (Sweller), constructivist perspectives (Piaget), sociocultural theory (Vygotsky), Activity Theory (Leontiev and Engeström), and Bloom's taxonomy—raises significant concerns about the indiscriminate use of GAI in education. These frameworks emphasize the need for active cognitive engagement, social interaction, and authentic motivation. The study revealed that GAI-related research tends to prioritize operational issues over foundational learning principles and highlighted the risks of uncritical GAI integration.

The practical implications point to the need for structured, developmentally appropriate strategies for GAI use. Educational institutions should prioritize teaching fundamental disciplines—logic, philosophy, linguistics, mathematics, and the arts—to foster deep analytical skills and offset potential adverse effects. The current GAI user population spans a wide range, from individuals—such as children and undergraduates—who may not yet have fully developed cognitive abilities, to those who, although also novice users of GAI, have acquired such skills through education prior to its widespread use. It can be argued that the latter are better equipped to engage critically with GAI due to their established evaluative skills. Evaluating GAI's impact on developing learners therefore requires longitudinal observation. Although it is still too early for definitive conclusions, efforts should begin now to prepare for understanding long-term outcomes. It is also crucial to raise awareness about the risks of uncritical GAI use among novice users, especially across various levels of education. Future research should focus on how GAI can support—rather than bypass—essential learning processes, by developing pedagogical techniques that balance technological integration with traditional learning practices while preserving active learning, social engagement, and motivation.

Several areas of future research are critical. Longitudinal studies should examine how early exposure to GAI affects schema formation, critical thinking, and knowledge transfer. Tracking these learners against historical cohorts could reveal shifts in cognitive flexibility and problem-solving. Additionally, cultural and socioeconomic contexts must be considered, as learning theories manifest differently across societies. Research into how GAI interacts with local knowledge systems, educational traditions, and diverse epistemological frameworks will support culturally responsive implementation. Studies exploring how GAI may either bridge or widen achievement gaps are essential for developing equitable strategies. Comparative policy research could identify which educational systems most effectively balance innovation with the protection of learning fundamentals.

This study's findings carry important policy implications and align with global trends in educational technology. While international initiatives (UNESCO, 2021, 2022; OECD, 2023; European Commission, 2020) acknowledge AI's potential, current frameworks tend to emphasize infrastructure and digital literacy. However, without equal focus on pedagogical foundations, such policies risk undermining essential learning processes. As education systems expand technology integration, policies must also safeguard cognitive development, social learning, and intrinsic motivation. This research contributes a theory-based perspective

to help shape more balanced and effective AI education policies.

Ethical considerations further complicate GAI implementation. The integration of GAI tools raises concerns regarding data privacy, as student interactions generate potentially sensitive information requiring robust protection protocols. Questions of accessibility and equity emerge as critical considerations—differential access to GAI tools across socioeconomic boundaries may exacerbate educational inequalities. For instance, the requirement to use specialized tools—such as tablets with styluses for handwritten submissions—may support cognitive development and aid in verifying authenticity, but it also introduces additional barriers for students with limited access to technological resources. Furthermore, potential biases in GAI systems—reflecting limitations in their training data—present challenges for ensuring fair educational experiences. Addressing these ethical concerns requires collaborative efforts among educators, policymakers, and developers to ensure GAI implementation upholds principles of privacy, equity, and fairness.

This study acknowledges several methodological limitations. The exclusive use of the SCOPUS database, while comprehensive, may have excluded relevant research indexed in other academic repositories. Furthermore, while the scoping review methodology effectively fulfilled the objective of providing a general panorama across diverse learner profiles, it necessarily sacrificed depth for breadth. A more targeted systematic review focusing on specific learner profiles or educational contexts would likely yield more detailed and nuanced results.

Declarations

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