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Integrating Generative AI in Collaborative Learning to Strengthen Engagement and Participation: A Systematic Review

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ABSTRACT

The integration of generative artificial intelligence (AI) into educational settings has attracted increasing attention for its potential to enhance collaborative learning, particularly by strengthening student engagement and participation. This study presents a systematic literature review that synthesizes existing research on the use of generative AI in collaborative learning environments across different educational levels. Guided by the PRISMA framework, the review analyzes how generative AI influences emotional, behavioral, cognitive, and agentic dimensions of student engagement. The findings indicate that generative AI consistently supports emotional and behavioral engagement by fostering motivation, confidence, and active participation, while its impact on cognitive engagement is more variable and strongly mediated by pedagogical design. Positive effects on agentic engagement are evident when generative AI is embedded within structured, teacher-facilitated learning activities that promote reflection and self-regulation. Furthermore, pedagogical approaches that integrate generative AI with human guidance tend to produce more balanced and sustainable engagement outcomes than stand-alone AI use. This study contributes an engagement-centered synthesis that positions generative AI as a socio-technical component of collaborative learning and provides theoretical, practical, and policy-relevant implications for its responsible and pedagogically aligned implementation in education.

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Introduction

The rapid development of artificial intelligence (AI), particularly generative AI, has fundamentally reshaped contemporary educational practices across primary, secondary, and higher education contexts (Gawlik-Kobylińska, 2024; Kim et al., 2022a; Xu, 2024a). Unlike earlier educational technologies that primarily functioned as content delivery or management systems, generative AI systems such as ChatGPT, Claude, and similar large language models (LLMs) are capable of producing ideas, arguments, explanations, and learning artifacts that directly intervene in students' cognitive and social learning processes (Aisha Irshad et al., 2025; Rachid et al., 2025; Zhu et al., 2023a).

This technological shift has renewed scholarly interest in the relationship between AI and collaborative learning. Collaborative learning has long been recognized as a powerful pedagogical approach for fostering deeper understanding, social negotiation of meaning, and higher-order thinking skills (Leahy et al., 2025; Ma & Zhong, 2025; Yan et al., 2024a). However, sustaining meaningful student engagement and equitable participation in collaborative settings remains a persistent challenge, particularly in large classes, online environments, and heterogeneous classrooms (Fan et al., 2025; Q. Liu et al., 2025a; Wei et al., 2024). Student engagement itself is now widely understood as a multidimensional construct encompassing emotional, behavioral, cognitive, and agentic dimensions (Abdelhalim & Almaneea, 2025; Dara et al., 2025; Qadir, 2025). Numerous studies have demonstrated that engagement is a critical mediator between instructional design and learning outcomes, especially in collaborative and inquiry-based learning environments (Guo et al., 2025; Ravi, 2025; Solanki, 2025). Consequently, any technological intervention that claims to improve learning quality must be examined primarily through its impact on engagement and participation, rather than merely on efficiency or performance metrics.

Recent studies suggest that generative AI holds considerable promise in this regard. Empirical evidence indicates that AI-supported collaborative activities can increase students' motivation, confidence, and willingness to participate in group discussions (Davlatova & Chernobay, 2025; Kanoksilapatham & Takrudkaew, 2025; Surendhranatha Reddy & Leelavathi, 2025). In writing-intensive and project-based contexts, generative AI has been shown to help students overcome initial idea-generation barriers, accelerate drafting processes, and support peer collaboration (Tran et al., 2025a). At the same time, the literature also reveals significant tensions. Several studies warn that uncritical use of generative AI may lead to cognitive dependency, superficial learning, and reduced originality (Xu, 2024a; Zhu et al., 2023b). Ethical concerns related to academic integrity, data privacy, and authorship are also widely reported (Aisha Irshad et al., 2025; Kim et al., 2022b; Rachid et al., 2025). These findings indicate that generative AI is not a pedagogically neutral tool; rather, its educational value depends heavily on how it is embedded within instructional design and classroom culture (Pahi et al., 2024; Sari et al., 2024; Solanki, 2025). From a theoretical perspective, recent scholarship increasingly frames the role of AI in education within the paradigm of *human–AI collaboration* and *collective intelligence* (Honigsberg et al., 2025; Woolley, 2025). In this view, AI should not replace human cognition or social interaction, but should instead function as a cognitive and social amplifier that enhances group thinking, dialogue, and knowledge construction (Dara et al., 2025; Fan et al., 2025; Qadir, 2025). This perspective aligns closely with contemporary theories of collaborative learning and self-regulated learning, which emphasize agency, metacognition, and shared epistemic responsibility (Haidar et al., 2025; W. Liu & Cui, 2024; Ravi, 2025).

However, despite the rapidly growing body of empirical studies, the existing literature remains fragmented in several important ways. First, many studies focus on specific disciplines (e.g., language learning, engineering, or teacher education) or specific educational levels, making it difficult to derive cross-contextual conclusions (Ma & Zhong, 2025; Tran et al., 2025b). Second, a substantial portion of the literature emphasizes learning outcomes or user perceptions, while fewer studies systematically analyze how generative AI affects different dimensions of student engagement within collaborative learning processes (Abdelhalim & Almaneea, 2025; Fan et al., 2025; Q. Liu et al., 2025b). Third, measurement approaches vary widely, with some studies focusing primarily on emotional and behavioral engagement, while others emphasize cognitive or agentic aspects, resulting in an uneven and sometimes inconsistent evidence base (Dara et al., 2025; Guo et al., 2025; Qadir, 2025). Fourth, although many authors stress the importance of pedagogical design, there is still no comprehensive synthesis that maps which instructional strategies, scaffolding models, and facilitation approaches are most consistently associated with positive engagement outcomes when using generative AI (Leahy et al., 2025; Pahi et al., 2024; Surendhranatha Reddy & Leelavathi, 2025).

These limitations point to several clear research gaps. To date, there is no systematic synthesis that specifically focuses on generative AI in collaborative learning, analyzes its impact across multiple dimensions of student engagement and participation, and compares findings across educational levels, disciplinary contexts, and pedagogical designs. Existing reviews tend to address AI in education in general terms or focus on performance and ethics, rather than on engagement as a central analytical lens (Gawlik-Kobylińska, 2024; Kim et al., 2022c; Xu, 2024b). Accordingly, this study offers three layers of novelty. First, at the conceptual level, it positions generative AI explicitly within the framework of collaborative learning and multidimensional student engagement, rather than treating it merely as an instructional technology. Second, at the methodological level, it employs a systematic literature review to integrate findings from diverse empirical contexts, research designs, and educational levels (Ma & Zhong, 2025; Yan et al., 2024b). Third, at the substantive level, it does not simply ask whether generative AI is “effective,” but instead examines *how*, *for whom*, and *under what pedagogical conditions* it strengthens or weakens engagement and participation.

The main objective of this study is therefore to address the following overarching question: How does the integration of generative AI in collaborative learning environments influence student engagement and participation across different educational contexts and pedagogical designs? To answer this question, this article systematically reviews recent empirical studies focusing on generative AI-supported collaborative learning from primary to higher education. The theoretical significance of this study lies in its contribution to the emerging literature on human–AI collaboration and technology-enhanced collaborative learning by providing a structured, engagement-centered synthesis of empirical evidence (Honigsberg et al., 2025; Woolley, 2025). The practical significance concerns its potential to inform teachers, instructional designers, and curriculum developers about evidence-based strategies for integrating generative AI in ways that genuinely enhance participation and deep learning rather than merely increasing efficiency (Leahy et al., 2025; Surendhranatha Reddy & Leelavathi, 2025; Tran et al., 2025b). From a policy perspective, the findings are also relevant for developing institutional guidelines that balance innovation, pedagogical quality, and academic integrity (Aisha Irshad et al., 2025; Kim et al., 2022c; Xu, 2024b). In sum, by systematically synthesizing a rapidly expanding but still fragmented body of literature, this study seeks to provide a comprehensive and theoretically grounded understanding of the role of generative AI in strengthening engagement and participation in collaborative learning.

Method

This study adopts a qualitative approach using a Systematic Literature Review (SLR) design combined with conceptual synthesis to systematically identify, analyze, and integrate empirical findings on the integration of generative AI in collaborative learning and its impact on student engagement and participation. The SLR method was selected because it enables a structured, transparent, and replicable process for collecting, evaluating, and synthesizing research evidence from diverse sources (Kitchenham et al., 2009; Snyder, 2019). This approach is particularly appropriate for studies aiming to develop integrative conceptual understanding and research-based synthesis rather than to test specific empirical hypotheses (Webster & Watson, 2002). Conceptual synthesis was employed to integrate concepts, theoretical perspectives, and empirical findings across studies into a coherent analytical framework focusing on engagement and participation in AI-supported collaborative learning (Jaakkola, 2020). This approach allows the identification of recurring patterns, conceptual relationships, and research gaps within the rapidly growing and multidisciplinary literature on generative AI in education.

The data sources consisted of peer-reviewed journal articles, proceedings of reputable international conferences, and academic books that address generative AI, collaborative learning, student engagement, and participation. Literature searches were conducted using major academic databases, namely Scopus, Web of Science, IEEE Xplore, ACM Digital Library, and Google Scholar, which are widely recognized as comprehensive and high-quality sources of scholarly publications (Falagas et al., 2008; Gusenbauer & Haddaway, 2020). The search strategy employed combinations of the following keywords: *"generative AI"*, *"ChatGPT"*, *"large language models"*, *"collaborative learning"*, *"computer-supported collaborative learning"*, *"student engagement"*, and *"participation"*. These keywords were combined using Boolean operators (AND, OR) to improve both the sensitivity and specificity of the search process(Kitchenham et al., 2009).

Clear inclusion and exclusion criteria were defined to ensure the relevance and quality of the selected studies, following established SLR guidelines (Kitchenham et al., 2009; Moher et al., 2009). The inclusion criteria were: (1) studies that explicitly examine the use of generative AI or large language models in educational contexts; (2) studies that address collaborative learning, group work, or social learning processes; (3) studies that report findings related to student engagement, participation, interaction, or related constructs; (4) publications in peer-reviewed journals, reputable conference proceedings, or academic books from credible publishers; and (5) studies that provide clear empirical or conceptual contributions. The exclusion criteria were: (1) non-scholarly publications or works not subjected to peer review; (2) studies focusing solely on technical aspects of AI without educational or pedagogical implications; (3) studies that do not involve learning or instructional contexts; and (4) publications with insufficient methodological or conceptual clarity.

The study selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and replicability (Moher et al., 2009; Page et al., 2021). The procedure consisted of four main stages: identification, screening, eligibility, and inclusion. At the identification stage, all potentially relevant records were retrieved from the selected databases. During screening, titles and abstracts were examined to remove clearly irrelevant studies. In the eligibility stage, full texts were assessed against the inclusion and exclusion criteria. Finally, studies that met all criteria were included in the final synthesis.

Several strategies were employed to ensure the trustworthiness of the review. Source validity was ensured by restricting the data sources to reputable journals, established academic publishers, and leading international conferences (Tranfield et al., 2003). Process validity was strengthened by applying explicit and well-documented SLR procedures to minimize selection bias (Moher et al., 2009). In addition, conceptual validity was enhanced through cross-study comparison to identify convergent and divergent findings related to the effects of generative AI on engagement and participation in collaborative learning (Webster & Watson, 2002). The reliability of the analysis was supported by applying consistent coding criteria, whereby a theme or pattern was only recognized as robust if it was supported by multiple independent and credible primary sources (Miles & Huberman, 1994). Data analysis was conducted using thematic analysis combined with conceptual synthesis. Thematic analysis was employed to identify recurring patterns and key themes in the literature through stages of open coding, theme development, and conceptual abstraction (Braun & Clarke, 2006). This procedure enabled the systematic identification of major forms of engagement (emotional, behavioral, cognitive, and agentic), pedagogical strategies, and implementation challenges in generative AI-supported collaborative learning.

In the subsequent stage, conceptual synthesis was used to integrate the identified themes into a coherent analytical framework explaining how and under what conditions generative AI supports or constrains student engagement and participation in collaborative learning contexts (Jaakkola, 2020). This stage involved analyzing relationships among themes, comparing perspectives across studies, and examining their theoretical and pedagogical implications, resulting in a structured understanding of generative AI as part of a socio-technical learning system. All stages of the review process, including search strategies, selection criteria, and analytical procedures, are documented in detail to ensure transparency and replicability. By applying the same databases, keywords, selection criteria, and analytical procedures, future researchers can replicate or extend the findings of this study (Kitchenham et al., 2009; Page et al., 2021).

Results

The studies reviewed in this research cover various educational levels, ranging from primary to higher education, with the majority of studies conducted in higher education contexts (Abdelhalim & Almaneea, 2025; Davlatova & Chernobay, 2025; Leahy et al., 2025). The research methodologies employed include quasi-experimental designs, mixed-methods approaches, and qualitative approaches (Guo et al., 2025; Ma & Zhong, 2025; Yan et al., 2024a). Most studies utilized generative AI based on Large Language Models, particularly ChatGPT, as a tool to support collaborative learning (W. Liu & Cui, 2024; Surendhranatha Reddy & Leelavathi, 2025; Tran et al., 2025b). The primary focus of outcome measurement encompassed the dimensions of emotional, cognitive, behavioral, and agentic engagement (Abdelhalim & Almaneea, 2025; Dara et al., 2025; Fan et al., 2025).

A number of studies reported that the use of generative AI in collaborative learning was associated with significant increases in students' emotional engagement (Abdelhalim & Almaneea, 2025; W. Liu & Cui, 2024; Tran et al., 2025b). These improvements were reflected in higher learning motivation, greater interest in group tasks, and increased student confidence in participation (Dara et al., 2025; Kanoksilapatham & Takrudkaew, 2025). A study by Davlatova & Chernobay (2025) also reported increased active participation in group discussions following the integration of generative AI into a station-rotation learning model. Behavioral engagement was likewise reported to increase, as evidenced by higher frequencies of student contributions to discussions, enhanced interaction among group members, and greater involvement in the completion of collaborative tasks (Leahy et al., 2025; Solanki, 2025; Surendhranatha Reddy & Leelavathi, 2025). Abdelhalim & Almaneea (2025) further reported that project-based learning supported by generative AI significantly increased students' levels of participation in group work.

Most studies also reported increases in cognitive engagement, particularly in activities involving critical thinking and problem solving (Fan et al., 2025; Q. Liu et al., 2025b; W. Liu & Cui, 2024). A study by Haidar et al. (2025) showed that the use of generative AI as a discussion support tool improved the quality of students' arguments and idea elaboration. Research by Ravi (2025) similarly reported improvements in students' conceptual understanding and reflective abilities in the context of engineering education. However, several studies noted that gains in cognitive engagement were not always as pronounced as increases in emotional or agentic engagement (Abdelhalim & Almaneea, 2025; Q. Liu et al., 2025b). Some studies also indicated that excessive reliance on AI could lead to shallow cognitive contributions and reduced depth of analysis (Masih et al., 2025; Zhu et al., 2023a).

Several studies reported that the use of generative AI supported improvements in students' agentic engagement, as indicated by increased initiative, self-regulation, and decision-making in the learning process (Abdelhalim & Almaneea, 2025; Dara et al., 2025; Fan et al., 2025). Research by Qadir (2025) showed that students were more active in directing their own learning processes when AI was used as a tool for reflection and task planning. A study by Haidar et al. (2025) also reported improvements in students' metacognitive abilities in managing their own learning strategies. Most studies indicated that pedagogical strategies combining generative AI with human facilitation produced more consistent outcomes than the use of AI alone (Abdelhalim & Almaneea, 2025; Pahi et al., 2024; Surendhranatha Reddy & Leelavathi, 2025). Project-based learning supported by generative AI was consistently reported to enhance student autonomy, leadership, and collaboration (Abdelhalim & Almaneea, 2025; Tran et al., 2025b). The integration of AI into blended learning models was also reported to improve engagement and academic performance (Davlatova & Chernobay, 2025; Solanki, 2025). A study by Leahy et al. (2025)

found that teacher-guided AI interventions tailored to disciplinary contexts improved learning efficiency and the quality of instructional interactions. Several studies also reported variations in the effectiveness of pedagogical strategies depending on educational level, scaffolding design, and intervention duration (Q. Liu et al., 2025b; Ma & Zhong, 2025). These differences were also reported to be influenced by the focus of measurement instruments, which in many cases emphasized emotional aspects more strongly than cognitive aspects (Abdelhalim & Almaneea, 2025).

Most studies reported improvements in students' academic performance in AI-supported collaborative learning environments (Davlatova & Chernobay, 2025; Tran et al., 2025b; Wei et al., 2024). These improvements included gains in cognitive learning outcomes, critical thinking skills, and communication skills (Guo et al., 2025; Ma & Zhong, 2025; Ravi, 2025). A meta-analysis by Ma & Zhong (2025) confirmed the positive effects of generative AI on students' cognitive domains and competencies. However, several studies reported that inconsistent definitions and indicators of learning outcomes made cross-study comparisons difficult (Q. Liu et al., 2025b; W. Liu & Cui, 2024). Some studies also noted the risk of superficial learning when AI is used without adequate pedagogical integration (Aisha Irshad et al., 2025; Xu, 2024b). The studies consistently reported that technical challenges constitute major barriers to the implementation of generative AI, including infrastructural limitations and inconsistencies in AI outputs (Gawlik-Kobylińska, 2024; Masih et al., 2025; Rachid et al., 2025). The digital divide was also reported to affect equitable access to AI technologies (Masih et al., 2025). Ethical issues, such as data privacy and academic integrity, were likewise frequently reported (Aisha Irshad et al., 2025; Kim et al., 2022c; Xu, 2024b). Resistance from educators and low levels of institutional readiness were also identified as obstacles to the widespread adoption of AI (Pahi et al., 2024; Sari et al., 2024; Surendhranatha Reddy & Leelavathi, 2025). Several studies noted that much of the existing literature tends to focus more on identifying problems than on offering concrete implementation solutions (Gawlik-Kobylińska, 2024; Rachid et al., 2025).

Finally, almost all studies emphasized the importance of maintaining a balance between the role of AI and the role of human educators (Abdelhalim & Almaneea, 2025; Pahi et al., 2024; Surendhranatha Reddy & Leelavathi, 2025). The *humans-in-the-loop* model was reported as the most frequently recommended approach (Honigsberg et al., 2025; Kim et al., 2022c). The studies also indicated that balanced human–AI interaction is associated with increased student autonomy, motivation, and critical engagement (Dara et al., 2025; Fan et al., 2025; Qadir, 2025). Conversely, several studies reported that excessive dependence on AI is associated with reduced dialogue quality and increased cognitive load (Fan et al., 2025; W. Liu & Cui, 2024).

Discussion

This study set out to examine how and under what pedagogical conditions the integration of generative AI in collaborative learning environments strengthens student engagement and participation. The findings of the systematic review suggest that generative AI consistently enhances emotional and behavioral engagement, shows more variable effects on cognitive engagement, and tends to support agentic engagement when embedded in well-designed pedagogical scenarios. These results can be meaningfully interpreted through established theories of collaborative learning, student engagement, and socio-cognitive scaffolding. The consistent increase in students' motivation, confidence, and participation reported across multiple studies (Davlatova & Chernobay, 2025; Kanoksilapatham & Takrudkaew, 2025; Reddy & Leelavathi, 2025; Tran et al., 2025) suggests that generative AI functions effectively as an *affective and interactional scaffold*. From the perspective of classical collaborative learning theory, this finding aligns with the notion that lowering participation barriers and increasing perceived competence are crucial for sustaining productive group interaction (Johnson & Johnson, 1999; Slavin, 2014). Generative AI appears to reduce the "entry cost" to discussion and joint problem solving by providing initial ideas, language support, and rapid feedback ((Ruiz-Rojas et al., 2024; Sumitro et al., 2025). This mechanism helps explain why students who are usually passive become more willing to contribute, a pattern also observed in technology-supported collaborative learning more broadly (Dillenbourg, 1999; Stahl, 2006). In this sense, the present findings extend earlier work on computer-supported collaborative learning (CSCL) by showing that generative AI does not merely mediate interaction but actively co-produces resources for interaction.

In contrast to the relatively uniform gains in emotional and behavioral engagement, the effects on cognitive engagement are more heterogeneous (Fan et al., 2025; Guo et al., 2025; Q. Liu et al., 2025b). Some studies report improvements in argumentation quality, conceptual understanding, and reflective thinking (Haidar et al., 2025; Ravi, 2025; Ruiz-Rojas et al., 2024), while others warn of superficial processing and overreliance on AI-generated outputs (Masih et al., 2025; Xu, 2024b; Zhu et al., 2023a). This pattern can be interpreted using the framework of *cognitive offloading* and *productive struggle*. From a socio-constructivist perspective, deep learning in collaborative contexts requires learners to engage in explanation, negotiation of meaning, and epistemic conflict (Dillenbourg, 1999; Stahl, 2006; Vygotsky, 1978). When generative AI is used as a shortcut rather than as a prompt for further reasoning, it may reduce opportunities for such cognitive, thereby weakening cognitive engagement (Fan et al., 2025; Woolley, 2025). Conversely, when AI is embedded in tasks that require critique, comparison, or revision, it can function as a cognitive catalyst rather than a cognitive substitute (Haidar et al., 2025; Leahy et al., 2025).

One of the most theoretically significant findings of this review is the relatively consistent positive impact of generative AI on agentic engagement, manifested in increased initiative, self-regulation, and strategic control over learning processes (Abdelhalim & Almaneea, 2025; Dara et al., 2025; Qadir, 2025). This aligns closely with contemporary theories of student engagement that emphasize agency as a core dimension, alongside behavioral, emotional, and cognitive components (Reeve, 2012; Fredricks et al., 2004). Generative AI seems to support students in planning, monitoring, and revising their work, thereby functioning as a form of *metacognitive scaffold* (Haidar et al., 2025; Ravi, 2025). From the perspective of self-regulated learning theory, this suggests that AI can expand learners' capacity for strategic control, provided that it is framed as a support for reflection rather than as an answer-generating machine (Woolley, 2025; Zimmerman, 2002).

A crucial cross-cutting insight from this review is that the educational value of generative AI is not intrinsic but *design-dependent* (Pahi et al., 2024; Solanki, 2025; Sari et al., 2024). Studies that integrate AI into project-based learning, structured collaboration, or guided inquiry report more robust and balanced gains across engagement dimensions (Tran et al., 2025; Leahy et al., 2025) than those that use AI as a stand-alone tool. This reinforces a long-standing principle in educational technology research: tools do not determine learning outcomes; pedagogical scripts and social arrangements do (Dillenbourg, 1999; Kirschner et al., 2004). In this regard, generative AI should be seen as part of an instructional orchestration system rather than as an autonomous instructional agent.

The review also indicates that improvements in engagement often coincide with improvements in learning outcomes (Ma & Zhong, 2025; Wei et al., 2024; Davlatova & Chernobay, 2025). This is consistent with classical models that position engagement as a mediator between instructional conditions and achievement (Fredricks et al., 2004; Slavin, 2014). From the perspective of knowledge-building theory, the most promising uses of generative AI appear to be those that support idea improvement, collective responsibility, and sustained inquiry rather than mere task completion (Scardamalia & Bereiter, 2026; Woolley, 2025). In this sense, the present findings suggest that generative AI can, under appropriate conditions, become part of the epistemic infrastructure of collaborative knowledge creation.

Theoretically, this study strengthens the emerging paradigm of *human–AI collaboration* by grounding it in empirical evidence about engagement processes (Hönigsberg et al., 2025; Woolley, 2025). It also extends engagement theory by showing how digital agents can influence not only behavior and emotion but also agency and metacognition (Fredricks et al., 2004; Reeve, 2012). Practically, the findings provide actionable guidance for teachers and instructional designers: AI should be integrated into collaborative tasks that require interpretation, critique, and co-construction rather than simple production (Leahy et al., 2025; Tran et al., 2025; Reddy & Leelavathi, 2025). From a policy perspective, the results underscore the need for institutional guidelines that emphasize pedagogical alignment, ethical use, and academic integrity (Irshad et al., 2025; Kim et al., 2022; Xu, 2024; Rachid et al., 2025). Despite the breadth of the reviewed literature, several limitations must be acknowledged. Many studies are short-term interventions and rely heavily on self-reported measures of engagement (Abdelhalim & Almaneea, 2025; Dara et al., 2025). There is also substantial heterogeneity in research designs, instruments, and contexts, which limits the possibility of strong causal generalization (Ma & Zhong, 2025; Yan et al., 2024). Furthermore, relatively few studies examine long-term impacts on higher-order thinking and collaborative expertise (Woolley, 2025; Guo et al., 2025). Nevertheless, these limitations do not undermine the central conclusion of this review: generative AI can meaningfully strengthen engagement and participation in collaborative learning, but only when embedded within sound pedagogical and epistemic designs.

Conclussion

This systematic review demonstrates that the integration of generative AI in collaborative learning environments consistently contributes to strengthening student engagement and participation, particularly in the emotional, behavioral, and agentic dimensions, while its effects on cognitive engagement are more context-dependent and strongly mediated by pedagogical design. Overall, the most robust findings indicate that generative AI is most effective when embedded within structured, teacher-guided collaborative learning models rather than used as a stand-alone tool.

The main contribution of this study lies in providing an engagement-centered synthesis of a rapidly growing but fragmented body of literature. Unlike previous reviews that primarily focus on learning outcomes, ethical issues, or general perceptions of AI in education, this study explicitly positions generative AI within the theoretical framework of collaborative learning and multidimensional student engagement. By systematically mapping how generative AI influences emotional, behavioral, cognitive, and agentic engagement across educational levels and instructional designs, this review advances the emerging paradigm of human–AI collaboration and offers a more nuanced understanding of generative AI as a socio-technical component of learning environments rather than merely as an instructional technology.

The findings carry several important implications. From a practical perspective, teachers and instructional designers are advised to integrate generative AI into collaborative tasks that emphasize inquiry, critique, co-construction of knowledge, and reflection, rather than simple content generation. Pedagogical models such as project-based learning, guided collaboration, and scaffolded inquiry appear particularly suitable for leveraging generative AI to enhance student participation, autonomy, and leadership. From a theoretical perspective, the results reinforce the central role of engagement—especially agentic engagement—as a key mechanism through which generative AI can support learning, and they extend engagement theory by highlighting the role of AI as a metacognitive and motivational scaffold. From a policy and institutional perspective, the study underscores the need for clear guidelines that balance innovation with pedagogical quality, ethical use, and academic integrity, as well as for investments in infrastructure and professional development to ensure equitable and responsible adoption of generative AI in education.

Despite these contributions, this review also points to several directions for future research. First, more longitudinal and design-based studies are needed to examine the long-term effects of generative AI on deep learning, collaborative expertise, and higher-order thinking. Second, future research should develop more standardized and theoretically grounded instruments for measuring the different dimensions of engagement in AI-supported collaborative learning. Third, there is a need for more comparative studies that systematically test different pedagogical designs, levels of teacher guidance, and forms of human–AI interaction. Finally, further investigation is required into how generative AI can be integrated into collaborative learning in ways that promote not only efficiency and participation, but also epistemic responsibility, critical thinking, and collective knowledge building. In sum, this study concludes that generative AI holds substantial potential to strengthen engagement and participation in collaborative learning, but this potential can only be realized through careful pedagogical design, strong human facilitation, and a clear commitment to educational values and learning goals.

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