AI-Assisted Instructions in Collaborative Learning in Mathematics Education: A Qualitative Approach

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ABSTRACT

This qualitative study, grounded in an interpretive paradigm, used a phenomenological methodology to explore the experiences of pre-service math teachers in three colleges of education in Ghana's Ashanti region. The sample included 50 participants. The results showed that people have positive views and attitudes about AI-assisted instruction. These views and attitudes can be broken down into four groups: general views, attitudes toward AI tools, the effects on collaboration, and ethical concerns. Factors influencing engagement in the learning experience included technological, pedagogical, social, psychological, and external elements. Key insights indicated that ease of use, instructor alignment with learning goals, and positive peer interactions enhance engagement. At the same time, challenges such as internet connectivity and access to devices can hinder it. The study recommends addressing misconceptions and equity issues to foster positive attitudes towards AI integration in mathematics education across all levels in Ghana.

Keywords: Artificial Intelligence (AI), AI- Assisted, Collaborative, Instruction, Attitude, Perception, Engagement

INTRODUCTION

Artificial intelligence (AI) has become a game-changing technology in business, industry, and society because of the concurrent advancements in digitalization, processing power, and data availability (Holmes et al., 2019). Globally, all industries are impacted by rapid technological advancements; hence, labor skills must be updated as quickly as possible (Gómez-Gamero, 2019; Mena-Guacas et al., 2023). Information and communication technologies are currently essential to education development because of their adaptability and versatility (García, 2021). In this regard, artificial intelligence (AI) utilization is drastically altering many facets of society, including educational institutions (Vera, 2023). Artificial Intelligence (AI) presents new opportunities to improve teaching and learning, and technological developments are increasingly influencing the subject of mathematics education. Recent years have seen the introduction of AI into educational settings to promote personalized learning, adaptive instruction, and real-time feedback—all of which are especially beneficial in disciplines like mathematics that call for sophisticated problem-solving and critical thinking abilities (Holmes et al., 2019). Research on artificial intelligence is now underway (Zawacki-Richter et al., 2019). The purpose of this study was to explore how pre-service teachers perceive and engage with AI-assisted collaborative learning, identifying factors that influence their experiences.

As AI technologies gain traction in educational spaces, there is a pressing need to understand how these tools impact the perceptions, engagement, and learning outcomes of pre-service teachers. Currently, few studies focus specifically on the role of AI in facilitating collaboration among pre-service mathematics teachers, leaving educators with limited insights into best practices and potential pitfalls (Ertmer & Ottenbreit-Leftwich, 2019'; Delgado et al., 2024). Although collaborative learning is a foundational aspect of teacher training, pre-service mathematics teachers often face unique challenges when engaging in collaborative learning environments facilitated by AI, such as balancing traditional mathematical practices with AI-driven insights and adjusting to new instructional approaches (García-Peñalvo et al., 2023). These challenges highlight an essential gap in our understanding of how AI shapes the learning experience, attitudes, and engagement levels of future mathematics educators. This study aims to address this gap by examining pre-service mathematics teachers' perceptions, attitudes, and engagement in AI-assisted collaborative learning environments.

Using a qualitative approach with a case study design, the research seeks to comprehensively understand how AI can support collaborative learning in teacher training contexts. The qualitative component of the study, in particular, focuses on

exploring participants' subjective experiences with AI tools, highlighting their perceptions, engagement factors, and the challenges they encounter in collaborative settings. This in-depth exploration will provide valuable insights into the role of AI in enhancing collaborative learning among future educators and inform strategies for the effective integration of AI in teacher training programs.

Unlike previous studies (Ertmer & Ottenbreit-Leftwich, 2019; Farrokhnia et al., 2023) that explore AI in general educational settings, this research specifically explores AI's impact on collaborative learning dynamics in a pre-service mathematics education context, making it a unique addition to the literature. By identifying key factors that influence engagement and perceptions in AI-supported environments, this study provides actionable insights for designing AI-facilitated collaborative learning experiences that can improve teacher preparedness in mathematics education. Moreover, the findings can guide the development of training programs that leverage AI to foster active engagement, collaborative problem-solving skills, and positive attitudes toward technology among pre-service teachers. This study thus advances our understanding of the intersection between AI, collaborative learning, and mathematics teacher preparation, offering a novel perspective on effective technology integration in education.

The trend of artificial intelligence (AI) utilization is drastically altering many facets of society, including educational institutions. AI presents new opportunities to improve teaching and learning, and technological developments are increasingly influencing mathematics education. As AI technologies gain traction in educational spaces, there is a pressing need to understand how these tools impact pre-service teachers' perceptions, attitudes, engagement, and learning outcomes. Few studies focus specifically on the role of AI in facilitating collaboration among pre-service mathematics teachers, leaving educators with limited insights into best practices and potential pitfalls.

Research Questions
1. *What are the perceptions and attitudes of pre-service mathematics teachers towards AI-assisted collaborative learning environments?*
2. *What factors influence the engagement of pre-service mathematics teachers in AI-assisted collaborative learning environments?*

LITERATURE REVIEW

The theory underpins this study is the Collaborative learning theory. Collaborative learning theory underpins the notion that learning is inherently a social process in which individuals construct knowledge through interaction and shared problem-solving (Vygotsky, 1978). This theory, with roots in Vygotsky's concept of the

Zone of Proximal Development (ZPD), suggests that collaborative learning environments allow learners to perform tasks they may not be able to accomplish independently, thus enhancing cognitive development. Collaborative learning is especially relevant in mathematics education, where problem-solving and logical reasoning are core elements, and group work has been shown to improve mathematical understanding (Fu & Hwang, 2018). The incorporation of AI tools into collaborative learning can potentially support these interactions by providing real-time feedback, enhancing communication channels, and personalizing learning trajectories (Luckin et al., 2022).

Globally, AI-assisted learning tools have been widely studied, with numerous findings underscoring their potential to foster collaboration and improve educational outcomes. A study by Holmes et al. (2019) in the United States showed that AI tools enhanced collaborative problem-solving among mathematics teachers by providing personalized feedback, allowing students to interact in real time, and offering insights into individual learning styles. The study highlighted that AI could significantly support mathematics instruction by enabling pre-service teachers to engage more actively and develop critical problem-solving skills.

Similarly, research by Lai (2021) in Taiwan revealed that AI-assisted environments improved communication and group dynamics in teacher training programs. His findings suggested that AI tools, when well-integrated, encouraged pre-service teachers to share ideas more openly, facilitated collaborative reflection, and helped resolve conflicts through data-driven insights. These benefits contributed to a more positive attitude toward collaborative learning and AI, aligning with the Technology Acceptance Model. However, challenges such as dependency on technology and issues related to data privacy were also noted, emphasizing the need for structured guidelines and ethical considerations when using AI in educational settings.

Finally, a study by Prilop et al. (2020) found that the use of digital tools in teacher training programs positively affected collaborative learning outcomes by enabling real-time feedback and promoting shared learning experiences among pre-service teachers. However, this study also highlighted challenges such as limited technological infrastructure and a lack of familiarity with advanced tools like AI, which can hinder effective collaboration in learning environments.

Technology has emerged as a crucial component of education in recent years. Teaching and learning methods that encourage active and constructivist learning are now prioritized. As a result, collaborative learning platforms like Moodle, Blackboard Collaborate, Google Classroom, and others have had to be developed (Ellikkal & Rajamohan, 2024). Constructivist learning is made possible for

students by these AI-assisted resources (Koranteng et al., 2013). As a result, they remove the time and distance constraints that have mostly prevented students from working together in conventional learning settings (Koranteng et al., 2020). There is proof that using these AI-assisted resources improves student performance (Islam, 2013). According to many educators, children who participate in more academic activities will be better able to attain these learning objectives (Ko, 2016).

One significant development in higher education has been the usage of collaborative learning platforms to assist student-centered learning strategies (Fu & Hwang, 2018). Moodle and other AI-assisted collaborative learning technologies are still widely used by educators. According to Straková and Cimermanová (2018), a collaborative learning AI-assisted tool is an interactive technology that facilitates efficient online communication and information processing between students. These solutions remove obstacles that impede cooperation, such as time and location difficulties. A lot of academics think that using these systems improves students' academic performance, learning process, and knowledge development (Alonso et al., 2015). Above all, they offer educational institutions an economical way to encourage students' involvement and active participation in class activities (Koranteng & Wiafe, 2019). Eraković and Topalov (2021) state user satisfaction determines academic engagement with AI-assisted collaborative learning. Collaborative learning has long been acknowledged as a successful educational strategy in teaching mathematics. It promotes collaborative problem-solving, active participation, and the growth of communication and interpersonal skills (Lee & Paul, 2023; Tzirides et al., 2025). By offering personalized prompts, tracking progress, and promoting knowledge exchange among students, incorporating AI into collaborative learning can potentially improve interactions (Luckin et al., 2022; Tlili et al., 2025).

RESEARCH METHOD

The research employs a phenomenological methodology, focusing on participants' lived experiences and their interpretations of those experiences. This design is particularly suited for exploring the meanings that pre-service teachers attribute to their experiences in AI-assisted learning environments, especially in collaborative settings. The study's research questions revolve around attitudes, perceptions, and the subjective factors influencing participation in AI-enhanced collaborative learning. The phenomenological approach requires the researcher to engage deeply with participants' narratives, often through interviews, to identify and understand the themes that characterize their experiences.

Participants

The study was conducted in the Ashanti Region of Ghana, specifically targeting pre-service math teachers from three educational colleges: Akrokerri College of Education, Offinso College of Education, and Wesley College of Education. The Ashanti Region, known for its diversity and economic contributions, provided a rich context for the research. The target population was level 200-400 pre-service math instructors for the 2024 academic year. The sample was comprised of 50 pre-service math teachers, selected through convenience and purposeful multi-stage sampling techniques. The sample included both male and female participants, aged between 21 and 32, who had completed their foundational education and were training to teach mathematics in primary schools.

Data collection involved a Multi-Focused Group Discussion (FGD), which allowed for a comprehensive exploration of participants' experiences and perceptions. Participants were put into five Focus Groups comprising 10 members each. The interviews were conducted in person to facilitate observation of nonverbal cues, and ethical considerations were adhered to, including obtaining informed consent from participants. The researcher transcribed the interviews and employed thematic analysis to analyze the data. This involved a systematic approach to identifying, analyzing, and reporting patterns in the data, following a modified version of Braun and Clarke's thematic analysis method.

RESULTS

Pre-Service Teachers' Perceptions and Attitudes Towards AI-assisted Collaborative Learning Environments in Mathematics Education

The study sought participants' perceptions and attitudes toward AI-assisted collaborative learning environments in mathematics education. The following sub-themes emerged from the muti-focus group discussions: General Perceptions, Attitudes Towards AI Tools, Impact on Collaboration, Personal Relevance and Usefulness, Ethical and Practical Concerns, as well as Future Use and Integration. Table 1 shows the sub-themes of the interview questions.

General Perceptions
Participants were asked to share their initial thoughts or impressions about using AI-assisted tools in collaborative learning environments for mathematics education, share any previous experience with AI tools in their own learning or teaching practice, how such experiences influenced their perceptions of AI in mathematics education and how they perceive the role of AI in supporting their learning process.

Table 1

Themes from Pre-Service Teachers' Perceptions and Attitudes Towards AI-assisted Collaborative Learning Environments in Mathematics Education

Emerging Themes	Interview Question
General Perceptions	a. What are your initial thoughts or impressions about using AI-assisted tools in collaborative learning environments for mathematics education? b. Have you had any previous experience with AI tools in your learning or teaching practice? c. How did these experiences influence your perception of AI in education? d. How do you perceive the role of AI in supporting your learning process?
Attitudes Towards AI Tools	a. How do you feel the AI tool influenced the dynamics of your collaboration with peers? b. Did the tool make group interactions more engaging or more challenging? c. How do you perceive the AI's role in balancing contributions among group members?
Impact on Collaboration	a. How comfortable do you feel working with AI tools in a collaborative environment? b. Do you think the AI tool respects and enhances your individual and group contributions? c. How confident are you in the AI's ability to assist you in solving mathematical problems collaboratively?
Personal Relevance and Usefulness	a. How relevant do you think AI-assisted learning tools are to your growth as a future mathematics teacher? b. What aspects of the AI-assisted environment felt most or least meaningful to you? c. Do you believe AI tools align with your preferred learning style?
Ethical and Practical Concerns	a. Are there any concerns or reservations you have about using AI in mathematics education? b. How do you perceive the ethical implications or limitations of using AI in collaborative learning?
Future Use and Integration	a. How likely are you to use AI-assisted instructions in your future teaching practices? b. What support or training do you think you need to effectively integrate AI-assisted instructions into your teaching practices?

The study ascertained that participant had developed a positive perception towards AI-assisted instructions even though some of them had a prior negative perception

of not developing critical thinking among learners. Though participants had had previous experience with AI tools, their inability to use them effectively had impeded their continuous usage, even in a collaborative manner. However, participants are now optimistic and were of the perception that AI-assisted instructions used collaboratively enhance learning, particularly in mathematics education.

FGD1, Participant 1 (P1) shared that; "my initial thought for AI tool was that it makes learners lazy and again impede critical thinking and creativity. However, my perception based on my experience now is that it makes working mathematics easy and very fast. Working in groups even makes it simpler."

FGD2, P3 disclosed that at first, I did not know about it, and I thought it took a lot of time regarding the time needed to do research. I have now been able to use Artificial Intelligence tools in my learning by researching certain things, and I also know how to calculate mathematical concepts. I can know if the answers I got are correct when I put in the data for it to be solved and then compare my answers. I perceive the role of AI to be of support to the learning process.

FGD3, P8 continued that …initially, I was having so many thoughts about AI-assisted tools in collaborative learning environments for mathematics such that the AI-assisted tools will make learning very easy for students, but it will also decrease learners critical thinking ability since AI will do all their work for them. I am of the perception that AI will help learners understand complex concepts. Understanding complex concepts will rather increase the critical thinking skills of the learners.

FGD5, P10 also shared that my initial thought about AI was that the AI apps were fake due to the scamming system, so I didn't believe in it. Based on the introduction of AI-assisted instructions, I have tried them and after using AI to solve some mathematics questions, I realized that it would help me in my educational system because it can solve all the questions that I wasn't able to solve, so I have formed a positive perception now.

FGD4, P9 added that I have used AI tools like Gemini, ChatGPT, Photomath, Grammarly, and Open AI to learn and do most of my assignments. They make learning faster and clearer for me. I have realized that AI tools can help with solving math problems easily because they provide quick solutions to math problems, saving time for students and teachers. Moreover, Using AI in education feels modern and exciting, which inspires students and makes learning fun.

Attitudes Towards AI Tools

The study enjoined participants to indicate how they feel the AI tool influenced the dynamics of their collaboration with peers, how the AI tools make group interactions more engaging or more challenging, and how they perceive the AI's role in balancing contributions among group members. The study's result revealed that participants had developed a positive attitude towards the integration of AI tools in the mathematics teaching and learning process in a collaborative environment. The participants revealed their utmost desire to adopt AI-assisted instructions in their teaching practice by employing the collaborative approach since such lessons make group interactions more engaging and also ensure a balanced contribution among group members.

A section of the participants revealed that;

> In AI-assisted teaching and learning in a collaborative environment, learners are grouped in the class and are encouraged to visit the AI tools to research what is going to be learned, and this leads to a better and easier understanding of the topic in mathematics. All students are engaged in learning by accessing the AI. I perceive a collaboration among students to ensure the sharing of ideas (FGD1, P10).

> …in my own opinion, AI-assisted tools help make teaching and learning mathematics attractive and lively. For example, at first, when there were no calculators, a lesser number of students would be seen participating during mathematics class, but today, most learners participate due to AI tools, which has shot up the number of mathematics lovers, especially when they learn in groups to collaborate and share ideas **(FGD2, P7).**

> AI-assisted tools make teaching mathematics interesting, making students love and engage themselves in studying mathematics. For example, AI-assisted tools provide more actively based strategies to be used in the classroom to engage learners to participate fully in the lesson, particularly in a collaborative manner **(FGD5, P2).**

Impact on Collaboration

How comfortable participants felt working with AI tools in a collaborative environment, their thoughts on whether AI tools respect and enhance individual and group contributions, and how confident participants were in the AI's ability to assist them in solving mathematical problems collaboratively were some of the questions posed to participants in soliciting for their perceptions on AI-assisted

instructions concerning impact on collaboration. Participants revealed varied perceptions since they had first-hand experience with AI-assisted instructions during the intervention phase. The various perceptions indicate that AI-assisted instructions, when used collaboratively, make learners feel comfortable and confident since their individual views and contributions are respected. Such instructions breed confidence in learners because they have developed a positive perception of AI's ability to assist them in solving mathematical problems.

> …in my own opinion, I think students learn from each other if teachers engage students with a lot of mathematical problems assisted by AI after the conventional way of teaching mathematics in the classroom. For example, grouping students and giving them problems to solve, and after deliberations within the group assisted by the AI, they will learn from each other as well as different methods of arriving at the same answer. Each member's view will be respected, and this will boost their confidence level **(FGD3, P3)**

Participant 4 from FGD4 shared that if the students are in groups solving problems with AI, they share and have a common idea for an answer. Group discussion will let them come out freely to give the procedure using the AI without wasting much time in a mathematics classroom.

Personal Relevance and Usefulness

Participants shared their perceptions on the relevance of AI-assisted learning tools to their growth as future mathematics teachers, aspects of the AI-assisted environment they felt most or least meaningful to them, and how they believe AI tools align with their preferred learning style. Participant's perceptions and attitudes toward the positive relevance and usefulness of AI tools. The results showed that participants saw AI-assisted instructions as a growth towards their teaching profession, and when used collaboratively, it suits all learning styles.

Some participants shared that;

> I think teachers would rather guide students to use AI as an assisted instruction in teaching and learning mathematics. The collaborative learning environment would be learner-centered for students to interact and solve their mathematical problems. I can say that the conventional way of teaching is different from this because it is time-consuming compared to teaching with AI-assisted instructions in mathematics. AI is faster than the conventional teaching method and would be helpful in my teaching profession **(FGD2, P1)**.

Since students have been able to understand complex concepts with the use of AI, it will boost their overall performance in mathematics. Teachers will refrain from being instructors or being at the center of teaching and learning to become facilitators. The roles of teachers in using AI-assisted tools will differ from the conventional teaching method. AI-assisted instruction is relevant and useful for professional growth and favors all categories of learning styles. When used collaboratively, it will provide a conducive atmosphere for learners **(FGD3, P1)**

FGD4, P1 further disclosed that "I believe that AI-assisted tools will impact students' engagement and participation in collaborative mathematics learning activities in the sense that, if learners find answers easier to a question, it will encourage them to always seek its assistance, thereby boosting their interest in mathematics. AI-assisted tools would make teaching mathematics interesting where students will love to engage themselves in studying mathematics."

Ethical and Practical Concerns
The study further posed to respondents: are there any concerns or reservations you have about using AI in mathematics education? How do you perceive the ethical implications or limitations of using AI in collaborative learning to seek their perceptions, which led to the sub-theme Ethical and Practical Concerns? Participants had developed the perception that AI-assisted tools employed in teaching and learning are practically feasible since it is a learner-centered teaching approach but must be guided and regulated by a teacher who acts as a facilitator. There is also the need to emphasize originality, creativity, and innovation, even in the face of AI-assisted tools.

Learners need to know when and how to use the tools appropriately and effectively. I envision the role of teachers to be guidance and facilitators, exposing learners to how they can use AI tools in solving mathematics and letting them understand that they should not solely depend on it but that its assistance will make it easier for them. Otherwise, originality and critical thinking will be killed **(FGD1, P2)**

I think that appropriate usage of these tools, that is, when and how these tools are used. Learners must be checked or whipped in line whenever they are using them while teaching and learning mathematics collaboratively. Notwithstanding, AI-assisted instruction is learner-centered **(FGD2, P2)**.

Though integrating AI tools in the teaching and learning process is a learner-centered approach, it is important to avoid making errors when

making an input. By paying heed to this, it will avoid the provision of wrong answers to students by the AI during its usage **(FGD3, P2)**.

Some participants also expressed concerns about access, inclusion, and privacy regarding the use of AI tools, even though it is practical to integrate AI tools in the teaching and learning process. For instance;

FGD4, P2 expressed that students should be taught not to misuse AI tools, and they should be fairly used by everyone. I think equity of access is one of the ethical considerations that is important when using AI.

FGD5, P2 was of the view that data privacy, thus ensuring the protection of personal information and clear policies, needed to be addressed when integrating AI tools in the teaching and learning process. Again, equity and inclusion form part of it. These considerations will influence positively because using AI tools must be confidential.

Future Use and Integration

Pre-service teachers' perceptions and attitudes towards AI-assisted collaborative learning environments in mathematics education also revealed concerns about future use and integration. Participants answered questions on how likely they were to use AI-assisted instructions in their future teaching practices and the kind of support or training they needed to effectively integrate AI-assisted instructions into their teaching practices. The findings indicate that respondents had developed a positive attitude towards AI-assisted instructions and expressed their views on its potential use in the teaching and learning of mathematics when they become professional teachers. They viewed AI-assisted instruction as a learner-centered pedagogy capable of enhancing the academic and professional growth of learners and teachers, respectively.

FGD1 and P9 shared that looking at the role of AI, it will help in collaborative learning and problem solving if it is used properly. For potential innovations, learners ought to be educated on the use of AI tools to improve the teaching and learning of mathematics to improve problem-solving and academic performance.

Other participants shared that;

> I envision that these tools will help many learners develop an interest in mathematics and tend to pursue it at a higher level. We must try to incorporate them right from our basic schools by making them affordable and accessible **(FGD2, P9)**.

I anticipate that the mathematics departments will start inculcating AI tools in teaching and learning to put learners at ease in learning mathematics. These tools must be made accessible easily in the classroom, and when we manage them well, they will help in the effective teaching and learning of mathematics. I want to employ this teaching pedagogy **(FGD3, P9)**.

I think in days or years to come, the usage of AI tools will help develop students' interest in learning mathematics. Potential innovation includes using the Artificial Intelligence tool for grading students. As teachers, we must follow this teaching and learning approach to harness the full potential of our learners and for our professional development, too **(FGD4, P9)**.

AI tools will grow students even more and create new ways of teaching and learning.
In the future, I expect AI tools to become even smarter, offering personalized lessons for each student and real-time feedback, and in years to come, we may have virtual teachers. Using AI tools helps teachers to plan lessons more effectively. It will further make the learning of mathematics easier, interesting, and enjoyable **(FGD5, P9)**.

Factors Influencing Student Engagement with AI-assisted in Collaborative Learning Environments

The study looked into the factors influencing student engagement with AI-assisted collaborative learning environments. The factors were broadly categorized under Technological Factors, Pedagogical Factors, Social and Collaborative Factors, Psychological Factors as well as External Factors.

Technological Factors
Questions centering on technological factors included how participants would describe their experience using the AI tools, technical issues (e.g., slow response) that affected their engagement, AI features, such as feedback or interactive tools that were helpful learning, how respondents would rate the AI's ability to adapt to students' individual learning needs and whether any concerns about data privacy or security impacted their willingness to use the AI tools.

The study ascertained that ease of use and accessibility in terms of how simple, user-friendly interfaces and engagement tools an AI tool provides can enhance engagement, whereas complex systems embedded in an AI tool can lead to frustration among students. Also, the ability of AI to personalize feedback or adapt

to individual learners' needs promotes sustained engagement during lessons. Notwithstanding, frequent technical issues or delays in AI responses can reduce students' motivation and engagement in AI-assisted lessons, but interactivity features like real-time collaboration, visualizations, and interactive simulations make learning more engaging. Concerns about data misuse or lack of security (Data Security and Privacy) also hinder full participation in the utilization of AI in teaching and learning among participants.

Some participants shared that;

> Some AI tools are user-friendly. With little or no guidance at all, learners can use it in their studies. As a teacher-trainee, I look forward to integrating some of these AI tools in my teaching and learning, however, how simple and user-friendly it may be will encourage engagement among learners **(FGD1, P6)**.

> The AI tool's ability to provide real-time and quick responses relevant to the needs of learners encourages engagement and its long-time usage. Learners become satisfied and will be engaged throughout their learning activities when the AI tool in use serves their needs in real-time **(FGD2, P6)**.

> Sometimes, if learners are not getting the feedback they want due to frequent technical issues or delays in AI responses, it reduces students' motivation and engagement. The gadgets used to access the AI, as well as internet connectivity, could cause delays, which make learners lose interest and engagement in AI-assisted lessons **(FGD3, P6)**.

> AI tools' ability to provide visuals and interactive simulations makes learning more engaging. However, concerns about data misuse or lack of security (Data Security and Privacy) may hinder the full participation of the utilization of AI in teaching and learning **(FGD4, P6)**.

Pedagogical Factors
Among the pedagogical factors were instructors' ability to align AI-assisted lessons with the learning goals of learners. If the AI tools are directly relevant to the learning objectives, students are more likely to be engaged. The quality of feedback where timely, accurate, and constructive feedback from AI-assisted tools increases engagement. It was also found that the AI tool's ability to offer tasks that are challenging but not overwhelming maintains interest and motivation. Pedagogically, if Instructors perform the role of a facilitator by providing guidance and support during AI-assisted instructions, it can effectively boost students'

engagement. Moreover, if AI tools provide gamification elements such as badges, points, or leaderboards, it can make learning more engaging.

For instance, Respondent 6 from FGD 5 shared that if teachers employ learner-centered methodologies and act as facilitators during teaching and learning, learners may develop the interest to participate and be fully engaged.

> More AI tools keep emerging, however, if the AI tools are directly relevant to the learning objectives, students are more likely to be engaged when integrated into teaching and learning **(FGD1, P7)**.

> …as learners are introduced to the various AI tools in the teaching process, the quality of feedback where timely, accurate, and constructive feedback from AI-assisted tools is provided may directly increase learners' engagement **(FGD2, P7)**.
> I will say that integrating AI into teaching and learning, especially at the basic level, is novel, however, if the AI tools are such that they can offer tasks that are challenging but not overwhelming, they will highly maintain interest and motivation, leading to enhanced engagement **(FGD3, P7)**.

> Through the teaching intervention, I have realized that teachers must act as facilitators when AI tools are integrated into the teaching and learning process. Moreover, if the AI tool employed provides gamification elements such as badges, points, or leaderboards, it can make learning more engaging **(FGD4, P7)**.

Social and Collaborative Factors
Social and collaborative factors were seen in terms of group dynamics, where positive interaction among peers, supported by AI, fosters engagement, while conflicts or unequal participation hinder engagement. Shared goals where there is a clear, common objective in the collaborative tasks motivate students to engage more deeply, while AI tools with communication abilities encourage and enhance communication among group members to improve engagement. Also, in a group where there is peer support, collaboration with peers using AI tools helps overcome challenges and sustain engagement.

> I have realized that using AI tools to teach in a collaborative environment is ideal. If the members in the groups collaborate in a manner that brings everyone on board, it enhances active participation, leading to engagement **(FGD1, P1)**.

Educators should encourage communication and collaboration learning among themselves using the AI so that they will all bring their suggestions about the concept for better understanding **(FGD2, P1)**.

Facilitators must set clear and common objectives for each group when integrating AI into teaching and learning. This will boost the groups' collaborative efforts during tasks to motivate students to engage more deeply **(FGD4, P1)**.
Collaboration with peers must be encouraged when using AI tools to help overcome challenges and sustain engagement. Learners' abilities may not be the same, so a group where peers support each other will sustain engagement **(FGD5, P1)**.

Psychological Factors
Participants were asked how confident they felt in their ability to use the AI tools effectively, how the use of AI tools made them feel more motivated or less motivated to participate in learning activities, how they find the AI tools useful for improving their understanding of mathematical concepts, moments where they felt anxious, frustrated, or skeptical about using AI and how certain features or elements of the AI tools sparked their curiosity or interest. The study found that students were more likely to engage with AI tools if they saw AI tools to improve their learning outcomes. Furthermore, students' self-efficacy, where they feel confident in their ability to use AI tools, motivation and interest arising from intrinsic motivation, curiosity, and relevance to personal goals or fear of AI due to anxiety or skepticism about AI replacing human interaction or control affect engagement.

FGD3 P3 disclosed that gone were the days when most people saw technology as a lazy approach to work. However, technology has come to stay, and AI provides the needed support for teaching and learning. Students are more likely to engage with AI tools if they see their value in improving learning outcomes.
FGD4 P3 added that confidence in the use of AI tools has a role to play, as students who feel confident in their ability to use AI tools are more likely to engage actively.

As part of psychological factors, intrinsic motivation, curiosity, and relevance to personal goals play critical roles in the acceptance and use of AI in learning. Learners who have developed anxiety or skepticism about AI replacing human interaction or control may feel reluctant to use its usage, which may affect engagement. Likewise, teachers may not integrate such a teaching approach into their lesson delivery at all **(FGD5, P3)**

External Factors

The study gathered from participants other external factors concerning time constraints, technical infrastructure, classroom environment, and parents/guardians' support or influence. Limited time to explore and use AI tools was found to hinder learners' full engagement. Moreover, poor internet connectivity or lack of access to appropriate technological devices was a limitation to students' engagement in AI-assisted instruction. The classroom environment, including factors such as noise level, seating arrangements, and teacher-student relationships, was among the external factors that influenced student engagement. In addition, participants revealed parental involvement and support as a motivating factor for engagement in AI-assisted instructions since most of the technological devices would be procured by parents or guardians for the learners.

The study gathered from some participants that;

> I must say that a conducive classroom environment where the teacher serves as a collaborator working alongside students, engaging in joint problem-solving skills, ensuring the ethical and responsible use of AI tools, and providing immediate feedback during lessons will enhance and sustain engagement among learners **(FGD1, P4)**

> …not all students may have access to the technological devices needed to access the AI tools. Support from parents/guardians in procuring these devices becomes evident. In situations where they cannot afford to demotivate learners **(FGD2, P4)**
> One of the factors is poor network. Again, tools like mobile phones and laptops are not adequate in our schools to distribute to students for collaborative learning in class. The cost of data bundles to access the internet is very high, which affects AI integration into teaching and learning **(FGD3, P4)**.

> In our schools, most of the classrooms are not learner-friendly. Inadequate furniture even affects proper seating arrangements, lack of electricity supply to the schools and their classrooms, high level of noise, heat, sunlight, and rain waters in times of rain prevents the use of technological tools which may be used to access AI or even sustain learners' engagement **(FGD4, P4)**.

DISCUSSION AND CONCLUSIONS

Participants' perceptions and attitudes were categorized into general perceptions, attitudes towards AI tools, impact on collaboration, personal relevance and

usefulness, ethical and practical concerns, as well as future use and integration. The study ascertained that participants had developed a positive perception and attitude toward AI-assisted instructions even though some of them had a prior negative perception of not developing critical thinking among learners. They now view AI-assisted instruction as a learner-centered pedagogy capable of enhancing the academic and professional growth of learners and teachers, respectively.

Akanzire et al. (2025) similarly found a positive perception among educators regarding the potential of Generative AI tools to enhance academic achievement, make teaching and learning more enjoyable, and address diverse classroom needs. Bergdahl and Sjoberg (2025) asserted that teachers are generally positive about the potential of AI in education. Furthermore, Sako (2024) and Pre- et al. (2025) found that AI-assisted collaborative learning promotes Critical Thinking skills in prospective teachers. The image generation and draft creation functions of generative AI can help alleviate barriers to collaboration among group members, such as cognitive dissonance in goal recognition and differences in perceptions.

Likewise, Paul and Elder (2020) found that when generative AI moderately reduces such "friction" caused by conflicting opinions and dissatisfaction, it improves the students' recognition of the importance of engaging with and evaluating opposing viewpoints fairly. Lin and Chen (2024) found that Teachers and students were of the perception that AI-integrated educational applications stimulate creativity, increase engagement, provide personalized feedback, offer emotional support, facilitate collaborative creativity, and make learning resources more accessible. Significant interest in learning how to effectively utilize these tools. Student participants expressed mixed attitudes towards AI, with ethical issues, loss of critical thinking skills, and over-reliance on technology being the chief concerns.

The factors influencing student engagement with AI-assisted collaborative learning environments were broadly categorized under Technological Factors, Pedagogical Factors, Social and Collaborative Factors, Psychological Factors as well External Factors. The study ascertained that ease of use and accessibility in terms of how simple, user-friendly interfaces and engagement tools an AI tool provides can enhance engagement, whereas complex systems embedded in an AI tool can lead to frustration among students. Also, the ability of AI to personalize feedback or adapt to individual learners' needs promotes sustained engagement during lessons. Pedagogical factors such as instructors' ability to align AI-assisted lessons with the learning goals of learners, the AI tools' relevance to the learning objectives of students, and the quality of feedback where timely, accurate, and constructive feedback from AI-assisted tools increase engagement.

Social and collaborative factors were seen in terms of group dynamics, where positive interaction among peers, shared goals, communication abilities, and peer support help overcome challenges and sustain engagement. The study found that students were more likely to engage with AI tools if they saw AI tools to improve their learning outcomes, students' self-efficacy, motivation, and interest. Time to explore and use AI tools, internet connectivity, access to appropriate technological devices, and classroom environment, including factors such as noise level, seating arrangements, teacher-student relationships, and parental involvement and support, were among external factors that influence student engagement.

The findings corroborate with Almulla (2024), who found key determinants of AI (ChatGPT) adoption among students where Interaction learning and collaborative learning emerged as significant factors influencing the adoption of ChatGPT for research support context. Information quality also played a crucial role in students' choice to continue using ChatGPT, where students were less inclined to rely on ChatGPT for their research needs when they encountered inaccurate or irrelevant information. Zawacki-Richter et al. (2019) and Song et al. (2025) found higher levels of trust are expected to make students more receptive to using AI, viewing it as a valuable learning tool, which contributes to a positive attitude toward AI adoption.

Similarly, Bati et al. (2024) investigated the factors influencing the perceptions of business students regarding the use of artificial intelligence (AI) and found a positive correlation between students' opinions and factors such as exposure to AI, trust in AI technology, awareness and knowledge of AI, behavioral intentions regarding AI use, and personal experiences with AI. Specifically, exposure to AI, awareness, and knowledge, and behavioral intentions significantly influence students' attitudes toward AI adaptation. O'Dea et al. (2024) found factors such as country of studies and prior learning about AI and not age or educational level to greatly impact GenAI literacy.

In conclusion, the study has found that pre-service mathematics teachers have developed a positive perception and attitude toward AI-assisted instructions. They view AI-assisted instruction as a learner-centered pedagogy capable of enhancing the academic and professional growth of learners and teachers. Concerns of not developing critical thinking and stifling creativity among learners have all been eroded. Pre-service mathematics teachers' attitude revealed their utmost desire to adopt AI-assisted instructions in their teaching practice by employing the collaborative approach since such lessons make group interactions more engaging and also ensure a balanced contribution among group members.

The various perceptions indicate that AI-assisted instructions, when used collaboratively, make learners feel comfortable and confident since learners' individual views and contributions are respected. Such instructions breed confidence in learners because they have developed a positive perception of AI's ability to assist them in solving mathematical problems.

Mathematics educators, parents/guardians, curriculum developers, and all related stakeholders should endeavor to shape teachers' and learners' perceptions and attitudes toward contributing to the integration of AI into the teaching and learning of mathematics, even at the earliest grades, by addressing misconceptions, ethical, equity access, and connectivity challenges.

The study further concludes that certain factors, technological, pedagogical, social and collaborative, psychological as well as external, influence student engagement with AI-assisted instructions in a collaborative learning environment. The ease of use and accessibility in terms of how simple, user-friendly interfaces and engagement tools an AI tool provides can enhance engagement, whereas complex systems embedded in an AI tool can lead to frustration among students. Also, the ability of AI to personalize feedback or adapt to individual learners' needs promotes sustained engagement during lessons. Pedagogical factors such as instructors' ability to align AI-assisted lessons with the learning goals of learners, the AI tools' relevance to the learning objectives of students, and the quality of feedback where timely, accurate, and constructive feedback from AI-assisted tools increase engagement.

Social and collaborative factors in terms of group dynamics where positive interaction among peers, shared goals, communication abilities, and peer support help overcome challenges and sustain engagement. Students are more likely to be engaged with AI tools if they see AI tools to improve their learning outcomes, self-efficacy, motivation, and interest. Time to explore and use AI tools, internet connectivity, access to appropriate technological devices, classroom environment, including factors such as noise level, seating arrangements, and teacher-student relationships, and parental involvement and support also influence student engagement.

It is recommended technological and pedagogical concerns are addressed through a robust mathematics curriculum across all levels that spells out specific AI tools that resonate with the Ghanaian context of education. Moreover, pre-service teachers need to be trained in the implementation of AI-assisted instructions, whereas in-service teachers are given training through workshops and Professional Learning Communities (PLCs).

Social and collaborative, psychological, and other external factors lie on educators, parents/guardians to address these factors to bring out the best in learners and ensure the need for collaboration, motivation, and easy access to technological devices to access the AI tools.

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