Computer-Supported Collaborative Learning: An Analysis of the Relationship Between Human Critical Thinking and the Use of Artificial Intelligence (AI)

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Abstract

This study explores the relationship between human critical thinking and the use of AI in CSCL environments. The integration of Artificial Intelligence (AI) into Computer-Supported Collaborative Learning (CSCL) environments represents a transformative development in education, reshaping traditional learning paradigms. CSCL leverages technology to facilitate collaboration among learners, enhancing critical thinking, problem-solving, and a deeper understanding of educational material. The introduction of AI tools such as intelligent tutors, adaptive learning systems, and automated feedback mechanisms further enhances these processes by offering personalization and improving group dynamics. The findings from this study revealed that AI tools can significantly enhance collaborative processes, including teamwork, communication, and conflict resolution. These results emphasize the need for balanced integration of AI tools to ensure they complement rather than replace human cognitive engagement. This research seeks to offer valuable insights for educators, policymakers, and developers aiming to optimize the role of AI in education while safeguarding critical thinking and learner autonomy.

Keywords: Artificial intelligence, Computer-Supported collaborative learning, Critical thinking, Education, Collaboration, Communication.

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1. INTRODUCTION

Education is continuously evolving with advancements in technology, and one of the most transformative developments in recent years is the integration of Artificial Intelligence (AI) into collaborative learning environments. Computer-Supported Collaborative Learning (CSCL) is a teaching approach that leverages technology to facilitate collaboration among learners, fostering critical thinking, problem-solving, and deeper understanding. By enabling interaction and collaboration beyond physical and temporal barriers, CSCL has revolutionized traditional learning paradigms, making education more accessible and inclusive. Hernández-Sellés et al. (2019). The intersection of CSCL and AI presents significant opportunities and challenges. AI tools such as intelligent tutors, adaptive learning systems, and automated feedback mechanisms have enhanced the ability of learners to engage in meaningful discussions and collaborative activities. However, their role in enhancing or decreasing human critical thinking remains an area of active investigation. Critical thinking characterized by the ability to analyze, evaluate, and synthesize information to form reasoned judgment is a cornerstone of effective learning. Understanding how AI influences these processes is crucial to optimizing educational practices and technology design. Tedla and Chen (2024)

This research is an exploratory study which aims to analyze the relationship between human critical thinking and the use of AI in CSCL environments. It investigates how AI tools shape learners' cognitive and collaborative behaviors, whether they enhance or diminish critical thinking capabilities, and how educators can strike a balance between AI support and human cognitive autonomy. A quantitative methodology was adopted, employing a survey of 105 participants to assess perceptions of AI's impact on cognitive and collaborative processes. Data analysis was conducted using SPSS, focusing on key variables such as the influence of AI on critical thinking, collaborative learning, and teacher involvement.

The findings offer valuable insights into how AI tools enhance collaborative processes while posing potential risks to independent cognitive engagement. The integration of AI tools into CSCL environments has a profound impact on both collaborative learning and critical thinking. Participants highlighted the benefits of AI in promoting effective communication, enabling equal participation, and providing real-time feedback. AI tools facilitated smoother group interactions and improved problem-solving capabilities, indicating their potential to enhance the overall learning experience. However, the findings also underscore the dual nature of AI's influence. While AI simplifies complex tasks and offers structured guidance, over-reliance on these tools can reduce opportunities for deep cognitive engagement. Participants noted a tendency for AI to replace some aspects of critical analysis, which risks diminishing the development of independent thinking skills essential for academic and professional growth.

2. BACKGROUND
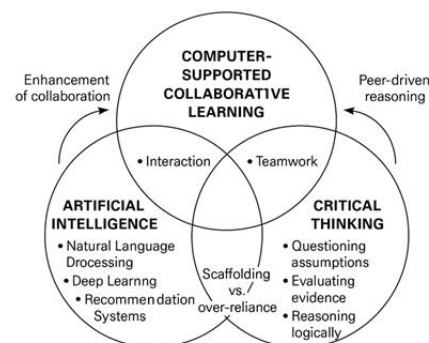
Figure 1: Conceptual framework showing the interplay between CSCL.

Figure 1 highlights how CSCL, AI, and Critical Thinking intersect. CSCL fosters collaboration through interaction, teamwork, and shared problem-solving. AI contributes by enhancing collaboration with tools such as NLP, deep learning, and recommendation systems, offering scalability and personalization, but also raising concerns of over-reliance. Critical Thinking develops as learners question assumptions, evaluate evidence, and reason logically, supported by CSCL's peer-driven dialogue. The overlap emphasizes that while AI can scaffold learning, its integration must safeguard

autonomy and deeper cognitive engagement

The integration of AI into CSCL holds immense potential to revolutionize collaborative learning by enhancing personalization, efficiency, and scalability. However, understanding how AI impacts learners' critical thinking, group dynamics, and overall educational outcomes remains underexplored. Critical thinking (CT) is a vital competency for success in academic, professional, and social contexts. It involves the ability to question assumptions, evaluate evidence, and reason logically. Within CSCL, CT is cultivated through interactions that challenge learners to defend their ideas, critique others' reasoning, and refine their arguments (Tedla & Chen, 2024).

While AI tools offer scaffolding that supports these processes, there is a risk of learners becoming passive recipients of AI-generated content rather than active participants in the learning process. Studies suggest that excessive dependence on AI may lead to surface-level engagement and hinder the deeper cognitive processes required for critical thinking. Thus, understanding the relationship between AI and critical thinking in CSCL is imperative for designing systems that empower, rather than decreasing cognitive growth and critical thinking (Warsah et al., 2021).

3. LITERATURE REVIEW

Computer-Supported Collaborative Learning (CSCL) has undergone significant advancements with the integration of Artificial Intelligence (AI), The integration of technology in collaborative learning environments has transformed educational practices, reshaping the way critical thinking and collaborative learning improve learning outcomes Rosé et al. (2008). A range of studies has examined various aspects of CSCL and the role of AI in enhancing collaborative processes. This literature review provides an in-depth analysis of the relationship between human critical thinking and the use of AI in CSCL environments, synthesizing findings from various studies.

Liu et al. (2023) focused on the use of technology in educational environments, particularly in facilitating collaborative learning through tools like concept mapping. The researcher focused on whether students' attitudes play a role in learning processes. The findings indicated a positive correlation between collaborative perceptions and knowledge acquisition, though factual knowledge understanding remained unaffected (Cress et al.,

2015). This suggests that fostering positive collaborative attitudes is vital for deeper engagement and learning outcomes.

Ada (2009) explored the role of CSCL in enhancing higher-order thinking skills within the context of textile studies. Higher-order thinking skills are cognitive processes such as analysis, evaluation, synthesis and creativity, which go beyond basic memorization or understanding and indicated that technological integration in educational settings improves learning outcomes. Collaborative environments were found to nurture these skills through high levels of social interaction and co-creation of knowledge, suggesting that integrating technology enhances cognitive processes essential for critical thinking. The results showed a positive link between the quality of group collaboration and the development of cognitive skills. High levels of social interaction and collaboration contributed to the establishment of a community of learning, nurturing a space for fostering higher order thinking through co-creation of knowledge processes (Radkowitsch et al., 2020).

Tedla and Chen (2024) conducted a meta-analysis on CSCL's impact on students' critical thinking, finding a moderate to large effect size. Factors such as group size and task complexity influenced outcomes, demonstrating that structured and interactive digital tools significantly promote critical thinking. The meta-analysis findings show that CSCL has a moderate effect on students' critical thinking skills. The results suggest that interactive, collaborative elements are effective components to promote critical thinking in computer-mediated environments across be many educational levels and subjects, under four specific conditions including group size and task complexity which might modulate the effectiveness of those effects. The overall ES estimate of the impacts of CSCL on CT was assessed using a random-effects model, and it was recorded as large (ES=0.854).

Warsah et al. (2021) examined and the impact of collaborative learning (CL) on learners critical thinking skills in addressing Islamic radicalism and their critical thinking retention and, investigated learners' perspectives on collaborative learning by using a mixed approach of 40 learners. The findings show that Learners taught by using collaborative learning experienced better critical thinking improvement and have good retention of their critical thinking skills compared to those taught means of lecturing.

Hu et al. (2022) compared different collaborative learning patterns and investigated effective patterns of group collaborative learning that were used in a digital AI course to promote fourth graders creative thinking and explored the difference between the four patterns in their promotion of students creative thinking in a seven-week teaching practice. Their results indicated that students that engaged in more interactive and collaborative groups demonstrate higher levels of critical thinking skills compared to those students that engaged in less interactive groups.

McLaren et al. (2010) examined the use of artificial intelligence (AI) techniques to support collaborative learning and e-discussions in educational settings. The study highlighted the importance of collaborative learning, where students work together to solve problems and discuss concepts. However, facilitating effective collaboration and ensuring productive discussions among students can be challenging, as instructors may struggle to manage and assess student interactions. To address this, the authors propose that AI can play a role in monitoring, guiding, and assessing collaborative learning environments. The result shows that AI plays a vital role in supporting collaborative learning by enhancing interaction quality, assisting instructors in managing discussions, and ultimately contributing to improved educational outcomes (Järvelä et al., 2015).

Ramirez (2021) investigated the effects of a CSCL environment with and without question-asking scripting on the development of conceptual understanding and critical thinking in science among middle school students. By comparing these CSCL approaches, the research sought to identify whether scripting activity specifically contributes to improved learning outcomes in critical thinking and science comprehension. The result shows that the CSCL environment significantly impacted students' conceptual understanding and critical thinking skills, with the greatest benefits observed in the group exposed to CSCL with question-asking scripting (Chu et al., 2024).

Chou et al. (2022) explored how human-computer interaction experiences and ICT self-efficacy influence the effectiveness of AI-based learning technologies and discusses the importance of artificial intelligence (AI) in education, particularly in information and communications technology (ICT) teaching, as AI technology becomes increasingly integral to modern learning environments. Their results indicated that the human-computer interaction experience significantly and positively relates to the effectiveness of AI-based technology applications, and that students' ICT self-efficacy has an indirect correlation with the learning effectiveness of AI-based technology application through the human-computer interaction experience (Andersen et al., 2022).

CSCL has been recognized as an effective approach to fostering higher-order cognitive skills such as analysis, evaluation, and synthesis (Ada, 2009). The dynamic and interactive nature of CSCL enables learners to co-construct knowledge through social interaction, which has been found to promote deeper understanding and critical thinking Altinay and Paraskevas (2007). By creating collaborative environments, CSCL allows students to engage in problem-solving and reflective activities that are essential for cognitive development (Hernández-Sellés et al., 2019).

McLaren et al. (2010) developed an AI-driven tool for e-discussions, which facilitated meaningful interactions and improved critical thinking outcomes by identifying unproductive patterns and offering real-time feedback. Similarly, Lee (2015) demonstrated that structured collaboration scripts, guided by AI, significantly enhanced students' reading literacy and critical engagement, suggesting that AI can adaptively refine collaboration frameworks to suit learners' needs.

4. METHODOLOGY

The research design was using quantitative methodology where we utilize a survey as the primary data collection tool to explore the relationship between human critical thinking and the use of artificial intelligence (AI) in computer-supported collaborative learning (CSCL). Subjects were recruited from the university student community. Standard testing was conducted for factor analysis and homogeneity of variance prior to proceeding with the analysis presented here within.
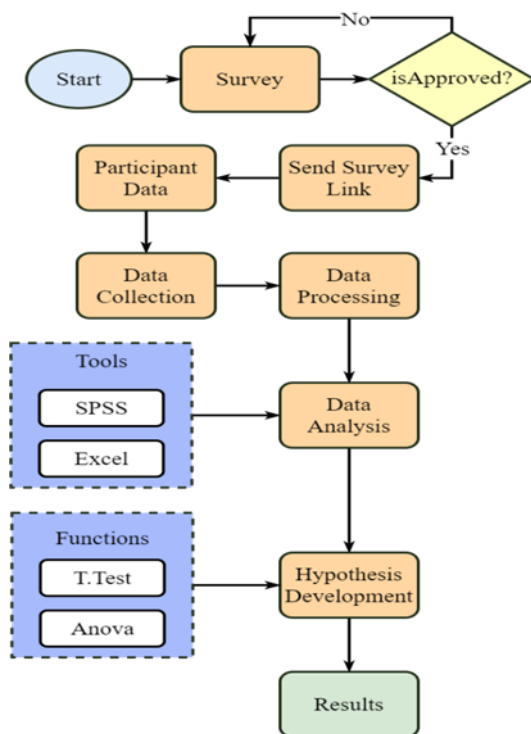
Figure 2: CSCL Flowchart

4.1 Hypothesis Development
This research aims to explore the relationship between human critical thinking and the use of artificial intelligence in a collaborative learning environment. Based on the research questions, the following hypotheses are formulated:

Research question 1: *Does the use of AI reduce critical thinking or enhance critical thinking?*
Research question 2: *Does AI tools enhance collaborative learning in CSCL?*
Research question 3: *Does Teachers involvement in collaborative learning have an impact on learner's learning skills in a collaborative environment?*
Research question 4: *Does the use of AI impact collaborative learning?*
Research question 5: *Does collaborative learning influence academic achievement among learners in a collaborative learning environment?*

These hypotheses form the basis for statistical tests to follow, including T-tests to examine binary group differences and ANOVA to explore differences across multiple group means.

4.2 Survey Development
The survey was approved by the Institutional Review Board (IRB) ensuring that all ethical guidelines for conducting research with human participants were strictly followed. Participants were informed of the study's purpose, their rights, and the confidentiality of their responses before providing informed consent. The survey questions were developed by combining key questions from seven papers on CSCL, human critical thinking, and AI. These papers were selected based on their relevance and contribution to the field and contribution to the IS literature.

The questionnaire was designed based on a 7-point Likert style scale on Qualtrics platform. The participants were recruited from university students and followed university recruitment protocols. Questions were adapted to align with the study objectives, ensuring clarity and relevance. The final survey consisted of six main sections:

- Demographics and Background Information
- Impact of Collaborative learning on Academic achievement
- Role of Technology and AI in Collaborative Learning.
- Impact of AI tools in collaborative learning and critical thinking
- AI's influence on critical thinking and group dynamics in collaborative learning
- Teachers' involvement in collaborative learning environments

5. RESULTS

The dataset for this research was designed and collected through a survey on Qualtrics platform aimed at examining and analyzing the relationship between human critical thinking and the use of artificial intelligence in a collaborative learning environment. A total of 105 responses were used for analysis to ensure the reliability and consistency of the dataset. The dataset consists of both demographic and behavioral variables; The participants spanned diverse age groups, Gender, Education level and Present Employment.

The behavioral variables were divided into five main sections; each section comprises seven questions focusing on a specific aspect of collaborative learning and AI integration

- **Impact of Collaborative Learning on Academic Achievement**: This evaluates how collaborative learning influences academic excellence.
- **Role of Technology and AI in Collaborative Learning**: This examines the integration of technology and AI in enhancing

collaborative learning environments.

- **Impact of AI Tools in Collaborative Learning and Critical Thinking**: This analyzes the impact of AI in collaborative learning and assesses the effectiveness of AI tools in enhancing or degrading critical thinking skills in a collaborative learning environment.
- **AI's Influence on Critical Thinking and Group Dynamics in Collaborative Learning**: This Analyzes how AI affects group interactions and critical thinking within collaborative learning environment.
- **Teachers' Involvement in Collaborative Learning Environments**: Examines the role of educators in facilitating collaborative learning using AI.

5.1 Data Cleaning and Analysis

To ensure the quality and integrity of the data, incomplete responses were excluded to maintain the reliability of the findings. The data analysis for this research was conducted using SPSS and excel to address six research questions that focus on Collaborative learning, Critical thinking and the role of artificial intelligence (AI) in a collaborative learning environment. Table 1 lists the specific questions and is presented in Appendix A. The results of the research questions are as follows:

5.2 The impact of AI on human critical thinking in a CSCL environment.

Research question 1: Does the use of AI reduce critical thinking or enhance critical thinking?

The impact of the use of AI on human critical thinking in a CSCL environment was measured using SPSS one way ANOVA. The results of the data analysis are presented in Table 2 below. Following Table 2 is a discussion of each of the factors.

		Sum of Squares	df	Mean Square	F	Sig.
INF1_1	Between Groups	69.902	6	11.65	3.424	**0.004**
	Within Groups	333.488	98	3.403		
	Total	403.39	104			
INF1_2	Between Groups	22.654	6	3.776	2.349	**0.037**
	Within Groups	157.536	98	1.608		
	Total	180.19	104			
INF1_4	Between Groups	18.182	6	3.03	2.41	**0.032**
	Within Groups	123.247	98	1.258		
	Total	141.429	104			
INF1_6	Between Groups	28.285	6	4.714	2.752	**0.016**
	Within Groups	167.849	98	1.713		
	Total	196.133	104			

Table 2: The impact of AI on human critical thinking in a CSCL environment.

INF1-1: "I believe AI would replace human critical thinking in collaborative learning environments". There is a significant F-value (3.424, **P = 0.004**), this result shows that people who engaged in collaborative learning using AI tools believe that AI reduces critical thinking.

INF1-2: "The use of AI tools in collaborative learning has helped me improve my critical thinking skills". There is a significant F-value (3.349, **P=0.037**), this result shows that reliance on AI tool in CSCL discourages independent thought.

INF1-4: "AI tools in collaborative learning allow me to better analyze the argument presented in group discussions". There is a significant F-value (2.41, **P=0.032**). This result shows that using AI to simplify analytical processes makes them less engaged in deep critical reasoning.

INF1-6: "AI facilitates equal participation among teammates during collaborative learning activities". There is a significant F-value (2.752, **P=0.016**). This result shows that AI enhances collaborative learning.

Based on the factors and the results in Table 2 it appears that AI tools have both positive and negative perceptions as regards their impact on critical thinking. For example, while many participants recognize the benefits of AI in collaborative learning, they also believe it has an impact on reducing critical thinking in the long run.

5.3 Relationship between AI and Collaborative Learning.

Research question 2: Does AI tools enhance collaborative learning in CSCL?

Table 3 presents evidence that indicates the use

of AI tools in a collaborative learning environment can significantly enhance collaborative learning by improving problem-solving, communication, idea generation, conflict resolution and corporation Following Table 3 is a discussion of each of the factors.

		Sum of Squares	df	Mean Square	F	Sig.
RT1_1	Between Groups	8.981	3	2.994	5.75	0.001
	Within Groups	52.581	101	0.521		
	Total	61.562	104			
RT1_2	Between Groups	10.558	3	3.519	4.416	0.006
	Within Groups	80.49	101	0.797		
	Total	91.048	104			
RT1_3	Between Groups	9.491	3	3.164	6.893	<.001
	Within Groups	46.356	101	0.459		
	Total	55.848	104			
RT1_4	Between Groups	12.314	3	4.105	6.49	<.001
	Within Groups	63.877	101	0.632		
	Total	76.19	104			
RT1_5	Between Groups	5.781	3	1.927	4.122	0.008
	Within Groups	47.21	101	0.467		
	Total	52.99	104			
RT1_6	Between Groups	7.725	3	2.575	5.841	0.001
	Within Groups	44.523	101	0.441		
	Total	52.248	104			

Table 3: Relationship between AI and collaborative learning.

RT1-1: "Role of Technology and AI in Collaborative Learning - Having access to computer-supported collaborative Learning has helped me to continue my studies to completion". This shows there is a significant difference in how often people perceive collaboration to enhance their learning and those who frequently engage in collaborative learning find it more beneficial

RT1-2: "Role of Technology and AI in Collaborative Learning - The use of AI tools in collaborative learning have helped me to collaborate more effectively". This shows there is a significant difference in how people view AI's ability to enhance effective teamwork and confirms that AI tools improve teamwork.

RT1-3: "Role of Technology and AI in Collaborative Learning - The collaborative learning forum allowed a fluid exchange of information". The result shows that there is a significant difference in perception of how AI influences problem-solving in collaboration environments and they believe that AI enhances problem solving by providing analytical tools.

RT1-4: "Role of Technology and AI in Collaborative Learning - The collaborative learning forum allowed a fluid exchange of information". This shows there is a significant difference between how AI facilitates discussions and generating ideas in group activity.

RT1-5: "Role of Technology and AI in Collaborative Learning - The collaborative learning environment has allowed me to establish personal connections with my teammates". The result shows that there is a significant difference between how AI tools is used to improve communication and task collaboration in a collaborative learning environment.

RT1-6: "Role of Technology and AI in Collaborative Learning - Collaborative learning has contributed to making me feel more involved in studying". The result shows that there is a significant difference in the AI ability to reduce conflict and brings corporation during group work.

5.4 Teacher's involvement in collaborative learning environment.

Research question 3: Does Teachers involvement in collaborative learning have an impact on learner's learning skills in a collaborative environment?

Based on the analysis as shown in Table 4 since TI1-2 and TI1-4 is (P < 0.05), there is a significant difference indicating that teacher involvement has an impact on learners' skills in collaborative learning environment particularly in areas that require active participation and guidance. Following Table 4 is a discussion of each of the factors.

		Sum of Squares	df	Mean Square	F	Sig.
TI1_2	Between Groups	18.52	3	6.173	7.555	<.001
	Within Groups	82.528	101	0.817		
	Total	101.048	104			
TI1_4	Between Groups	21.616	3	7.205	8.952	<.001
	Within Groups	81.298	101	0.805		
	Total	102.914	104			

Table 4: Teacher's involvement in collaborative learning environment.

TI1-2: "The teachers accompanied the students in an appropriate way to favor learning within collaborative environments". The result shows there is a significant difference in learners' perception of teachers' involvement in collaborative learning, it shows that teacher's involvement in collaborative learning enhances learners' ability to work effectively in a group.

TI1-4: "The teachers contributed to developing links with the learning community formed by each team and with other students". The result shows that there is a significant difference in learner's perception of how teachers' involvement impacts their skills. It confirms that teachers' involvement in collaborative learning enhances critical thinking.

5.5 Impact of AI on Collaborative Learning.

Research question 4: Does the use of AI impact collaborative learning?

Based on the analysis shown in Table 5, the overall result shows that there is a statistically significant difference in the impact of collaborative learning on academic achievement and the role of AI in collaborative learning environments. Following Table 5 is a discussion of each of the factors.

	t	df	Significance		Mean Difference	95% Confidence Interval of the Difference	
			One-Sided p	Two-Sided p		Lower	Upper
CL1_1	24.837	104	<.001	<.001	1.571	1.45	1.7
RT1_2	19.296	104	<.001	<.001	1.762	1.58	1.94

Table 5: Impact of AI on collaborative learning.

CL1_1: "Impact of collaborative learning on academic achievement - I often engage in collaborative learning". The result shows there is a statistically significant difference between collaborative learning on academic achievement. The mean difference of 1.571 and P value < 0.05 shows that AI tools significantly enhance collaborative learning.

RT1_2: "Role of technology and AI in collaborative learning - The use of AI tools in collaborative learning has helped me collaborate more effectively". The result shows that there is a significant difference between the impact of AI tools on the effectiveness of collaboration in learning environment. The mean difference of 1.762 and P value <0.05 shows that AI tools make collaboration more effective.

5.6 Impact of AI on Collaborative Learning.

Research question 5: Does collaborative learning influence academic achievement among learners in a collaborative learning environment?

Based on the analysis shown in Table 5, it appears that collaborative learning significantly impacts academic achievement and enhances knowledge sharing and interaction in a collaborative learning environment. Following Table 6 is a discussion of each of the factors.

		Sum of Squares	df	Mean Square	F	Sig.
CL1_2	Between Groups	14.474	3	4.825	11.355	**<.001**
	Within Groups	42.916	101	0.425		
	Total	57.39	104			
CL1_3	Between Groups	19.884	3	6.628	13.574	**<.001**
	Within Groups	49.316	101	0.488		
	Total	69.2	104			
CL1_4	Between Groups	6.925	3	2.308	6.604	**<.001**
	Within Groups	35.303	101	0.35		
	Total	42.229	104			
CL1_5	Between Groups	22.152	3	7.384	5.586	**0.001**
	Within Groups	133.505	101	1.322		
	Total	155.657	104			
CL1_6	Between Groups	9.367	3	3.122	4.801	**0.004**
	Within Groups	65.681	101	0.65		
	Total	75.048	104			

Table 6: Learner's perspectives on collaborative learning

CL1_2: "My team members have given me support, help and support through collaborative learning". Since **P < 0.05**, this shows support provided by team members in a collaborative environment has a great impact in positively influencing academic achievement.

CL1_3: "Collaborative learning has helped me achieve good academic achievement and development". Since **P < 0.05**, this shows that there is a significant difference in learners' perceptions of the role of collaborative learning in achieving academic success and development.

CL1_4: "Teamwork has allowed me to complement my knowledge with that of my teammates". Since **P < 0.05,** this shows there is a significant difference in learners' perspectives on how teamwork complements their knowledge in a collaborative learning environment

CL1_5: "The collaborative learning environment has allowed me to establish personal connections with my teammates". Since **P < 0.05,** this shows that there is a significant difference between when learning through interaction with teammates compared to when studying alone.

CL1_6: "The teachers guided their students in the process of forming the collaborative learning environment". Since **P < 0.05,** this shows that there is a significant difference between the time spent on collaborative learning and the benefits in achieving academic excellence.

6. DISCUSSION

This study advances current knowledge on the intersection of Artificial Intelligence (AI), Computer-Supported Collaborative Learning

(CSCL), and critical thinking. Consistent with prior research Ada (2009), Tedla and Chen (2025), the results confirm that collaborative learning environments enriched with technology foster critical thinking by promoting communication, interaction, and co-construction of knowledge. Participants in this study reported that AI tools facilitated equal participation, smoother group interaction, and improved problem-solving, which aligns with McLaren et al. (2010), who demonstrated that AI-driven systems can guide and enhance collaborative discussions. Similarly, Hu et al. (2022) found that highly interactive group patterns supported by digital tools significantly enhanced creative and critical thinking, reinforcing the positive role of AI-enabled CSCL identified here.

Also, this research highlights a tension less frequently emphasized in prior studies: the potential of AI to diminish deep cognitive engagement. While (Liu et al., 2023) and Ramirez (2021) stress the benefits of structured AI-supported environments for enhancing conceptual understanding, our findings suggest that over-reliance on AI may discourage independent reasoning and reduce opportunities for learners to practice critical analysis. Participants noted that simplification of analytical processes by AI sometimes led to passivity, which contrasts with the uniformly positive conclusions drawn by Warsah et al. (2021) regarding collaborative learning's impact on critical thinking. This divergence underscores the importance of considering not just whether AI improves collaboration, but how it may simultaneously reshape learners' engagement with higher-order thinking.

Teacher involvement emerged as a critical moderating factor in our study, with results indicating that active facilitation by educators balanced the risks of AI dependency. This finding complements Kasepalu et al. (2022), who noted that AI-supported pedagogical interventions require human oversight to ensure authentic cognitive engagement. Yet, our results go further by quantifying this role, showing that teacher participation significantly influenced learners' perceptions of skill development and critical engagement. This emphasis on the interplay between AI and human facilitation distinguishes the present study from earlier work, which often evaluated AI or CSCL in isolation.

Overall, the dual findings that AI simultaneously enhances collaboration and risks diminishing independent thinking position this research at the forefront of debates on the "double-edged" role of AI in education. Unlike previous studies that primarily documented benefits, this study makes a unique contribution and offers a more nuanced perspective, stressing the need for balance. it frames AI not as an unequivocal enhancer of critical thinking, but as a tool whose value depends heavily on context, user agency, and teacher mediation.

6. CONCLUSIONS

This research highlights the relationship between human critical thinking and the use of artificial intelligence in a collaborative learning environment. While AI tools improve collaboration and real-time feedback, they also risk diminishing critical thinking if over-relied upon. Effective integration requires a balanced approach, where educators play a central role in guiding cognitive and collaborative processes. Future research should focus on developing adaptive AI systems that support rather than supplant critical thinking and address ethical concerns such as data privacy and algorithmic bias. The insights from this study offer a roadmap for designing AI-enhanced CSCL systems that empower learners and optimize educational outcomes. By balancing technological advancements with human oversight, educators and developers can create learning environments that not only enhance collaboration but also empower learners to think critically, innovate, and excel in an increasingly digital world.

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Appendices and Annexures

Table 1: Questionnaire

Sources	Questions	Question Codes
Hernández-Sellés et al. (2019)	I often engage in collaborative learning.	CL_1
	My team members have given me support, help and support through collaborative learning.	CL_2
	Collaborative learning has helped me achieve good academic achievement and development.	CL_3
	Teamwork has allowed me to complement my knowledge with that of my teammates.	CL_4
	I have learnt more interacting with my teammates than when I study alone.	CL_5
	The teachers guided their students in the process of forming the collaborative learning environment.	CL_6
	The Teachers guided their students in the process of forming a collaborative learning environment.	TI1_1
	The teachers accompanied the students in an appropriate way to favor learning within collaborative environments.	TI1_2
	The teachers guided their students to develop teamwork skills that allow them to work more effectively.	TI1_3
	The teachers contributed to developing links with the learning community formed by each team and with other students.	TI1_4
Kasepalu et al. (2022) and Ouyang and Zhang (2024)	Interacting with my teammates has improved my grades than when I was studying alone	CL_7
	Having access to computer-supported collaborative Learning has helped me to continue my studies to completion.	RT1_1
	The use of AI tools in collaborative learning has helped me to collaborate more effectively.	RT1_2
	The collaborative learning forum allowed a fluid exchange of information.	RT1_3
	The team's discussion in a collaborative learning forum allowed establishing personal links.	RT1_4
	The collaborative learning environment has allowed me to establish personal connections with my teammates.	RT1_5
	Collaborative learning has contributed to making me feel more involved in studying.	RT1_6

Sources	Questions	Question Codes
Ada (2009)	I believe AI could suppress human critical thinking.	RT1_7
	I frequently use AI-supported tools in a collaborative learning environment.	IM1_1
	I believe AI tools enhance critical thinking by providing better insights and suggestions in collaborative tasks.	IM1_2
	AI improves my decision-making process in group work.	IM1_3
Tedla and Chen (2024), Hu et al. (2022), Warsah et al. (2021)	I believe AI supported tools reduce critical thinking	IM1_4
	I believe AI tools make collaborative learning more efficient.	IM1_5
	I believe AI tools affect collaborative learning processes by automating too much.	IM1_6
	The use of AI tools in collaborative learning would create bias opportunities.	IM1_7
	I believe AI would replace human critical thinking in collaborative learning environments.	INF1_1
	The use of AI tools in collaborative learning has helped me improve my critical thinking skills.	INF1_2
	The use of AI tools in collaborative learning environments encourages deeper discussions during group work.	INF1_3
	AI tools in collaborative learning allow me to better analyze the argument presented in group discussions.	INF1_4
	I feel more empowered to make critical decisions within the teammates when using AI tools in a learning environment.	INF1_5
	AI facilitates equal participation among teammates during collaborative learning activities.	INF1_6
	AI provides personalized feedback that helps me improve my critical thinking in group tasks.	INF1_7