



Applicability of ChatGPT in Online Collaborative Learning: Evidence Based on Learning Outcomes

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Abstract

The study delves into the impact of ChatGPT, a generative AI technology, on online collaborative learning (OCL) outcomes in educational settings. With a focus on knowledge activation and critical thinking, this research involved thirty university students from various disciplines, divided into experimental (ChatGPT) and control (traditional online search) groups. The research employed a mixed-methods approach, combining a controlled experiment with semi-structured interviews. Quantitative data were analysed using independent sample t-tests and ANCOVA, with IBM SPSS Statistics 28 used for statistical analysis. Qualitative data from interviews were analysed thematically using NVivo 12. The research process involved controlled experiment and semi-structured interviews. Results revealed a significant disparity in knowledge activation levels between the experimental and control groups, showcasing the efficacy of ChatGPT in enhancing students' engagement with challenging concepts. Furthermore, the study underscored ChatGPT's role in fostering critical thinking skills, thereby enriching the learning experience and promoting deeper understanding among participants. The findings shed light on the potential of AI technologies, like ChatGPT, to serve as virtual tutors, guiding learners through problem-solving tasks and facilitating metacognitive skills development. The research contributes to the evolving landscape of education technology, emphasizing the significance of AI-driven tools in augmenting educational practices and enhancing student learning outcomes. This study paves the way for further exploration of AI integration in educational contexts, offering insights into the transformative potential of generative AI technologies like ChatGPT.

Keywords: ChatGPT, Online Collaborative Learning, Critical Thinking, Knowledge Activation

1. Introduction

1.1 Research Background and Significance

In recent years, Artificial Intelligence (AI) has developed rapidly (Liu et al., 2018). AI refers to the ability of computers to simulate human intelligence, such as human learning capabilities, problem-solving abilities, etc (Stuart & Peter, 1995). AI can be divided into Discriminative AI and Generative AI according to the models used (Jebara, 2012). Discriminative AI mainly learns the conditional probability distribution of data and judges and predicts new scenarios. Generative AI, on the other hand, mainly learns the joint probability distribution in data and summarizes it, thus generating new content such as text, images, audio, video, etc. The development of AI technology has gone through the stages of machine learning, neural networks, and large language models (Lu, 2019; Myers et al., 2024).

At present, generative AI has received widespread attention in various industries (such as finance, healthcare, education, etc.), especially in the field of education (Göçen & Asan; Yu & Guo, 2023). Generative AI can assist teachers in teaching, learning, management, decision-making, etc (Baidoo-Anu & Ansah, 2023). In the era of Internet, more and more learners choose online collaborative learning (OCL) as one of their main learning methods (So, 2009). However, learners encounter various problems when participating in OCL, such as low learning performance (Chen, Wang, & Zhao, 2022) and weak critical thinking (Zhang et al., 2023). To solve these problems, this study aims to use a chatbot (ChatGPT) based on generative AI to help improve OCL performance and critical thinking. ChatGPT, the full name is Chat Generative Pre-trained Transformer, is an artificial intelligence chat robot program developed by OpenAI (Prajapati et al., 2024). At the same time, this study also compares the differences in knowledge activation between ChatGPT and online search. From the theoretical level, this study explores the contribution of ChatGPT to OCL and the new mode of human-computer collaboration. From the practical level, it explores how to use chatbots based on generative AI to improve learning performance.

1.2 Research Objectives and Research Questions

The main goal of this study is to test whether ChatGPT, compared to traditional online search, can significantly improve knowledge activation, OCL performance, and critical thinking. In this study, online search refers to traditional search engines without chatbot support. According to the research objectives, the following research questions are proposed:

1. Can ChatGPT significantly improve knowledge activation?
2. Can ChatGPT significantly improve OCL performance?
3. Can ChatGPT significantly improve critical thinking?
4. What contribution does ChatGPT provide in OCL?

2. Literature Review

2.1 Online Collaborative Learning

Online collaborative learning (OCL) has become an important learning method in the Internet era and has been widely adopted in higher education. OCL refers to a learning method in which multiple learners conduct synchronous or asynchronous online learning through the Internet and collaboratively solve problems for a common learning goal (Reeves, Herrington, & Oliver, 2004). Studies have shown that well-designed and reasonably implemented OCL can

enhance learning performance (Ng, Chan, & Lit, 2022), problem-solving skills, etc (Rosen, Wolf, & Stoeffler, 2020). OCL is divided into synchronous and asynchronous and is highly favoured in practical teaching.

However, OCL sometimes fails to achieve the desired results. The main reasons are that many learners only engage in simple information exchange and sharing in collaborative learning, which is not in-depth (Yang, Li, & Xing, 2018), group members often go off-topic (Wu, 2022), and learners lack timely feedback leading to abandonment of collaborative learning (Hernández-Sellés, Muñoz-Carril, & González-Sanmamed, 2019). To improve OCL performance, it is essential to provide learners with timely, personalized feedback. Feedback refers to information about personal performance or ideas provided by an agent (such as teachers, peers, parents, self, machines, etc.)(Hattie & Timperley, 2007). In the field of collaborative learning, researchers provide personalized feedback to learners in various ways. Martinez-Maldonado (2019) gave personalized feedback to learners based on the analysis results of handheld dashboards. Tan and Chen (2022) provided feedback and improve collaborative knowledge construction through peer interaction. Also, some researchers use conversational agents to provide feedback to learners, thereby enhancing students' motivation and participation in collaborative learning (Xie, Liu, Chen, & Liu, 2021). However, there is little research on chatbots based on generative AI providing comprehensive, personalized feedback to learners participating in OCL. This study aims to use ChatGPT to provide real-time, personalized feedback to learners during the collaborative learning process and to compare the differences between ChatGPT and those without chatbots.

2.2 Knowledge Activation

Knowledge activation refers to the process by which learners engage with and apply their existing knowledge to construct new understandings (Hattan, 2024). In the context of OCL, knowledge activation plays a crucial role in facilitating meaningful interactions among learners. Jonassen and Kim (2010) emphasized the importance of activating prior knowledge as a foundation for new learning experiences. Online environments offer various tools and strategies to stimulate knowledge activation, including collaborative discussions, problem-solving activities, and peer feedback mechanisms. The integration of ChatGPT in OCL offers unique opportunities for knowledge activation. By interacting with ChatGPT, learners can articulate their thoughts, clarify misunderstandings, and receive immediate feedback, thereby activating and refining their existing knowledge. For example, Cronje (2024) demonstrates how ChatGPT can serve as a virtual peer in group discussions, prompting deeper reflection and enhancing knowledge construction processes. Additionally, ChatGPT can adapt its responses based on learners' needs and learning objectives (Firat, 2023), which may provide tailored support for knowledge activation across diverse contexts.

2.3 Critical Thinking

Critical thinking is a key competency that enables individuals to analyse information, evaluate arguments, and make informed decisions (Lai, 2011). In OCL environments, critical thinking skills are essential for engaging with complex topics, solving problems, and participating effectively in discussions (Posey & Lyons, 2011). Warsah, Morganna, Uyun, Afandi, and Hamengkubuwono (2021) highlight the importance of promoting critical thinking through collaborative learning, reflective dialogue, and authentic problem-solving activities. Moreover, collaborative learning environments provide opportunities for learners to engage in peer feedback (Lerchenfeldt, Mi, & Eng, 2019), perspective-taking (Ke et al., 2019), and constructive debate (Chinn & Clark, 2013), all of which contribute to the development of critical thinking skills.

ChatGPT serves as a cognitive tool that supports learners' information processing and sense-making processes (Rasul et al., 2023). By generating relevant explanations, posing thought-provoking questions, and offering alternative perspectives, ChatGPT prompts learners to think critically about the content under discussion. Moreover, ChatGPT can facilitate argumentation and reasoning by providing evidence, counterarguments, and logical explanations in response to learners' queries or assertions (Marbun, 2023). In collaborative learning environments where argumentation and debate are central, ChatGPT's contributions can enrich discussions by presenting different viewpoints and supporting evidence. This not only exposes learners to diverse perspectives but also encourages them to critically evaluate arguments, weigh evidence, and construct well-reasoned conclusions. Additionally, ChatGPT's ability to generate coherent responses based on contextual inputs ensures that learners receive relevant and meaningful feedback (Rasul et al., 2023), which is essential for refining their critical thinking skills. Furthermore, ChatGPT's role in facilitating collaborative learning activities enhances learners' ability to engage in constructive dialogue and peer interaction (Al Shloul et al., 2024). Through exchanges with ChatGPT and peers, learners practice articulating their ideas, defending their viewpoints, and responding to feedback—a process that fosters intellectual flexibility, open-mindedness, and the willingness to reconsider one's own beliefs in light of new evidence or perspectives. Thus, ChatGPT's presence in OCL not only supports individual critical thinking skills but also contributes to the cultivation of a collaborative and intellectually vibrant learning community.

3. Method

This study combined quantitative and qualitative methods. The quantitative research methods included the controlled experiment and questionnaire, while the qualitative research included interview. The controlled experiment aims to compare the differences between ChatGPT and online search in terms of knowledge activation, OCL performance, and critical thinking. The questionnaire aims to clarify the status of students' critical thinking by assessing their perceptions or understanding. The interview aims to investigate students' real feelings about using ChatGPT in depth.

3.1 Participants

This study recruited a total of 30 students from S university at Shenzhen, China, majoring in computer science, education technology, education, psychology, etc. The 30 students were divided into 5 experimental groups and 5 control groups, with 3 students in each group. To detect whether there are differences in existing knowledge levels, all students have undergone pre-tests. According to the pre-test results, there was found to be no significant difference in existing knowledge levels between the experimental group and the control group ($t=0.254$, $p=0.806$).

3.2 Process

The research process of this study includes three steps. The first step is pre-testing, which involves testing all students on existing knowledge about AI technology and big data. Groups are formed according to the test results to ensure that there is no significant gap in existing knowledge between the experimental group and the control group. The second step carried out OCL. Before this, demonstrations and training on the use of OCL platforms and ChatGPT were necessary. The OCL tasks include three sub-tasks: discussing the key technologies and applications of AI, the relationship between big data and AI, and conducting in-depth analysis of the given four cases and evaluating their pros and cons, the impact on learning, and their

improvement plan. When each group completes the specified tasks, the main viewpoints and solutions formed are uploaded to OCL platform as group works. In order to avoid the influence of confounding variables, all tasks, duration, requirements, etc., of OCL for the experimental group and the control group are exactly the same, and the difference is only in different search method used when group discussion. The experimental group carries out ChatGPT, while the control group carries out traditional online search. The third step mainly involves post-testing and interview, that is, post-testing of participants' critical thinking, and semi-structured interview with all students of experimental groups, in order to understand students' feelings about using ChatGPT.

3.3 Measurement

The pre-test was compiled by experienced teachers and then judged by two research assistants. The reliability was calculated using the K-value, resulting in 0.89, which indicates good consistency. The questionnaire of critical thinking was adapted from Yeh (1999), consisting of 20 items and with a five-point scale. The Cronbach's α value of the questionnaire is 0.864, indicating good reliability. In addition, the ChatGPT is the version of ChatGPT 3.5.

Knowledge activation in this study is calculated according to method of Instruction Information Set (IIS) (Zheng, Yang, & Huang, 2010). This algorithm uses the information entropy theory to calculate the knowledge activation. To ensure the objectivity of the analysis, two researchers analysed the information flow of all groups, and the reliability was calculated using the K-value. The result was 0.83, indicating good consistency.

The OCL performance was primarily evaluated based on the quality of group work according to the evaluation scale, including argument, evidence, reasoning, and result. The full score for each parts is 25 points, and the total score is 100 points. Two researchers independently review each group's works according to the evaluation scale. K-value is 0.84, indicating good consistency.

3.4 Data Analysis

The data analysis in this study encompassed both quantitative and qualitative methods to comprehensively evaluate the impact of ChatGPT on knowledge activation, OCL performance, and critical thinking. For the quantitative analysis, IBM SPSS Statistics 28 was employed for statistical computations. Independent sample t-tests were used to compare pre-test and post-test scores between the experimental group (ChatGPT) and the control group (traditional online search) to assess changes in knowledge activation, OCL performance, and critical thinking. Reliability checks were performed using Cronbach's alpha. Statistical tests, including normal distribution tests and ANCOVA (Analysis of Covariance), were conducted to analyse data normality and examine differences in OCL performance and critical thinking between the experimental and control groups.

For the qualitative analysis, NVivo 12 was utilized to manage and analyse the interview data. Semi-structured interviews were conducted with all students in the experimental groups to gather in-depth insights into their experiences using ChatGPT. These interviews aimed to understand participants' perceptions of ChatGPT's role in enhancing knowledge activation, OCL performance, and critical thinking. The interview data were subjected to thematic analysis by two researchers, who identified common themes and insights, confirming reliability with a K-value of 0.88.

The findings from the quantitative and qualitative analyses were cross-validated to provide a holistic understanding of ChatGPT's contributions. This involved triangulating data from the controlled experiment, questionnaires, and interviews to draw robust conclusions

about the efficacy of ChatGPT in enhancing OCL outcomes. By employing these data analysis methods, the study ensured a rigorous evaluation of ChatGPT's impact on learners, providing evidence-based insights into its potential to transform online collaborative learning environments.

4. Results and Discussion

4.1 Knowledge Activation

Firstly, all data for knowledge activation follow a normal distribution ($p > 0.05$). Secondly, an independent sample t-test is used to examine the difference in knowledge activation between the experimental group and the control group. The statistical analysis ($t = 2.903$, $p = 0.02$) revealed a significant difference in knowledge activation between the control group ($M = 220.90$, $SD = 104.03$) and the experimental group ($M = 670.85$, $SD = 330.53$), with the knowledge activation of the experimental group being significantly higher than that of the control group.

The interviewees indicated that ChatGPT is very helpful in learning knowledge and skills. Through dialogues, they can not only acquire new knowledge but also adjust or change learners' ideas, thereby enhancing knowledge activation. For example, student C mentioned, "ChatGPT provides a lot of knowledge, it's very smart. I had little understanding of generative AI before, but through dialogues with it, I learned a great deal about generative AI and benefited immensely". Student F stated, "ChatGPT can also help correct some misconceptions. It constantly adjusts and changes my original ideas, allowing me to understand related knowledge more accurately until I am fully satisfied".

Moreover, in comparison to traditional online search, which tends to offer less focused and often irrelevant information (Wu, 2022). As Firat (2023) mentioned, ChatGPT can adapt its responses to learners' needs, facilitating more meaningful learning interactions. As noted by the participants, ChatGPT's feedback helped refine their understanding, echoing findings from prior studies that link AI-driven feedback with enhanced learning performance (Martinez-Maldonado, 2019; Xie et al., 2021).

4.2 Online Collaborative Learning Performance

The score of OCL performance evaluates the quality of group works. Firstly, all data satisfy the normal distribution ($p > 0.05$). Secondly, the statistical analysis results show that the variance of the post-test is homogeneous ($F = 0.167$, $p = 0.694$). It means that well-designed OCL environments can significantly enhance learning performance (Ng et al., 2022). Additionally, the interaction between the group and the pre-test is not significant ($F = 1.868$, $p = 0.221$), satisfying the parallel test. Finally, analysis of covariance (ANCOVA) is used to check the difference in OCL performance between the experimental group and the control group. According to the statistical results ($F = 7.112$, $p = 0.032$), a significant difference in OCL performance was found between the control group ($M = 79.00$, $SD = 4.30$) and the experimental group ($M = 86.80$, $SD = 4.43$).

Interviewees generally believe that ChatGPT can not only help provide comprehensive information but also provide suggestions for modifying group work. Student B believed, "The information provided by ChatGPT is comprehensive and more inspiring, which can stimulate me to generate new ideas". Student C believed, "ChatGPT provided valuable suggestions and feedback on our group work, helping us constantly modify and optimize it, and the quality of work has greatly improved". It highlights ChatGPT's role in stimulating peer-to-peer

exchanges, and demonstrates how ChatGPT fosters collaborative knowledge construction by offering unique perspectives and aiding in the refinement of group work.

ChatGPT provides precise views from different perspectives, and some views are quite novel and unique, which helps learners to broaden their minds and inspire creativity. Secondly, when learners cannot supply theoretical support, ChatGPT can provide factual and theoretical evidence (Rosen et al., 2020). After judgment, learners added appropriate and sufficient theory when completing group work. Thirdly, in the process of reasoning, ChatGPT assists learners in using various methods to support their views and ideas for reference. Finally, ChatGPT evaluated and checked the conclusions put forward by each experimental group and gave suggestions of modification. However, learners in the control group do not receive this support and assistance, resulting in significantly higher OCL among the experimental group compared to the control group.

4.3 Critical Thinking

First, this study checked whether there is a significant difference in existing critical thinking between the control group and the experimental group. According to the pre-test results, there is no significant difference between the control group and the experimental group ($t=0.346$, $p=0.733$). Secondly, the statistical analysis results show that the variance of critical thinking in post-test is homogeneous ($F=0.865$, $p=0.360$). In addition, the interaction between the group and the pre-test is not significant ($F=0.001$, $p=0.971$), which satisfies the parallel test. Finally, ANCOVA is used to determine the difference in critical thinking between the experimental group and the control group. According to the results ($F=15.01$, $p=0.001$), there was a significant difference in critical thinking between the control group ($M=3.51$, $SD=0.32$) and the experimental group ($M=4.27$, $SD=0.42$). It emphasizes the role of collaborative learning in fostering critical thinking through peer interaction and feedback (Warsah et al., 2021).

Similarly, students also feel that when using ChatGPT, they need to independently think and identify ChatGPT answers so that they can get better answers. "ChatGPT provided a lot of answers, so I need to judge whether the content it provides is correct and which answers are reasonable. I need to constantly criticize its answers" (Student A). Also, Student H stated, "When I use ChatGPT, I can't completely trust it. I will try to verify or refute its answers in other ways". Considering the reason, first, because ChatGPT is powerful, it can provide comprehensive answers to learners' questions and evaluate group works. However, learners need to choose suitable and correct answers or suggestions from it. Therefore, learners need to invoke critical thinking to question and criticize the chatbot's answers. Second, although ChatGPT can provide comprehensive answers, learners cannot fully trust the provided answers. Therefore, learners need to use other methods to test the answers or suggestions of the chatbot, which also enhances their critical thinking (Chinn & Clark, 2013).

4.4 Contributions of ChatGPT in OCL

Students A stated "ChatGPT has been really helpful in our online discussions. Whenever we hit a roadblock or needed clarification on a concept, we would just ask ChatGPT, and it would provide explanations that were easy to understand. It felt like having a knowledgeable peer in our group discussions". Student G also gave the same words, "ChatGPT has been a game-changer for us. In our research group, we often have complex discussions about our projects. Having ChatGPT there to provide explanations or suggest alternative approaches has been invaluable. It's like having an expert on hand whenever we need it". Interviewees also believed that compared to online search, ChatGPT have a greater contribution. They can provide not only more targeted information but also improve efficiency. For example, student F mentioned, "ChatGPT can provide more specific and useful information and answer

questions directly". "ChatGPT has strong integration ability and high efficiency, and its contribution in this aspect is greater than online search" (Student A). ChatGPT contributed significantly to the collaborative learning process by providing timely, context-specific feedback, which enhanced both individual and group learning outcomes. This is consistent with the findings of Chen et al. (2022), who emphasized the importance of peer feedback in improving collaborative knowledge construction. As ChatGPT acted as a virtual peer, it contributed to the continuous refinement of group work, facilitating higher-quality outputs and more productive exchanges (Zhang et al., 2023).

Therefore, ChatGPT contributes to OCL by providing personalized support to learners. Through adaptive responses tailored to individual needs and learning styles, ChatGPT can address misconceptions, offer explanations, and scaffold learning experiences. ChatGPT can scaffold complex concepts in OCL. By breaking down challenging topics into digestible explanations and providing real-time assistance, ChatGPT supports learners in navigating difficult concepts and deepening their understanding. Research illustrates how ChatGPT can serve as a virtual tutor, guiding students through problem-solving tasks and promoting metacognitive skills development (Kılınç, 2023; Lin, 2023). Also, ChatGPT facilitates collaborative interactions among learners by serving as a mediator in online discussions and group activities. Its presence encourages active participation, fosters peer-to-peer learning, and promotes knowledge sharing within learning communities.

5. Conclusion

This study used controlled experiment to examine the impact of ChatGPT on knowledge activation, critical thinking and OCL performance. The research results show that compared with traditional online search, ChatGPT indeed have a clear advantage in knowledge activation, and they can also significantly improve OCL performance and critical thinking. Different from traditional research that only focuses on learners' performance, this study uses an information flow-based analysis method to test knowledge activation and critical thinking in a OCL context, thereby objectively analysing the value and contribution of chatbot in education. However, due to the limitations of the research sample and context, the conclusions drawn from this study cannot be generalized yet. In the future, we will continue to expand the research sample and broaden the research context to test the replicability of the research.

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