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The Use of AI Chatbots in Study Group Learning to Improve Students' Self-Efficacy in Renewable Energy Materials in Class X of High School

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A B S T R A C T

Students' self-efficacy in learning physics is often still low, particularly in abstract topics such as renewable energy, which leads to low participation and confidence in learning. Therefore, an effective learning approach is needed to improve students' self-efficacy. This study aims to analyze the effectiveness of Artificial Intelligence (AI)-based chatbots integrated into study group learning to improve students' self-efficacy. This research used a quasi-experimental method with a nonequivalent control group design conducted at SMAIT Al-Fityah Pekanbaru involving class X students. The sample consisted of 46 students divided into experimental and control classes. Data were collected using self-efficacy questionnaires administered before and after treatment and analyzed using N-Gain, paired sample t-test, and independent sample t-test. The results showed that the average N-Gain in the experimental class (0.57) was higher than in the control class (0.32), both categorized as medium. These findings indicate that the integration of AI chatbots in study group learning is effective in improving students' self-efficacy and supports more interactive and meaningful learning.

1. Introduction

Education plays an important role in developing students' potential through the learning process, where students are expected not only to understand the material but also to develop 21st-century skills such as innovation, critical thinking, and the ability to utilize information technology. Teachers are also required to implement innovative learning strategies to create meaningful, engaging, and adaptive learning environments in accordance with current educational demands. However, international assessments such as PISA indicate that students' science achievement in Indonesia is still below the international average, which reflects the need for improvement in the quality of science education (Fatkhurrohman, 2024). Learning success is influenced by various factors, both internal and external, and one of the important internal factors

is self-efficacy (Rosandhi et al., 2025). Self-efficacy refers to an individual's belief in their ability to accomplish tasks and overcome challenges. Students with high self-efficacy tend to be more confident, persistent, and motivated, whereas those with low self-efficacy tend to doubt their abilities and become passive in the learning process (Ifiana, 2024). Previous studies have shown that students' self-efficacy in physics learning is still relatively low, characterized by hesitation, fear of making mistakes, and lack of confidence in answering questions (Widodo et al., 2022). This condition negatively affects students' participation and learning outcomes, indicating the need for effective learning strategies that can improve both conceptual understanding and students' confidence.

One of the learning strategies that can be applied is study group learning, which emphasizes collaborative learning through group interaction. In this approach, students work together to discuss problems, exchange ideas, and support each other in understanding the material (Faris Anwar et al., 2024). Collaborative learning environments provide opportunities for students to actively engage in discussions and develop their communication and problem-solving skills. In addition, the implementation of group learning has been proven to improve student activity and learning outcomes, particularly in science learning (Bakara & Hutahayan, 2021). Science learning, especially physics, involves abstract concepts that require appropriate learning approaches to facilitate understanding. Renewable energy is one of the important topics in science learning, as it is closely related to environmental issues and sustainability. Therefore, effective learning media are needed to help students understand the concepts and increase their awareness of energy-related issues (Wakidah, A., 2022).

Along with the rapid development of technology, the use of Artificial Intelligence (AI) in education has become an innovative solution to support interactive learning. AI enables systems to perform tasks that mimic human intelligence, such as providing information, answering questions, and assisting problem-solving processes (Michael Sitorus, 2023). In the educational context, AI can support personalized learning and provide immediate feedback to students (Kamal et al., 2025). One of the implementations of AI in education is the use of chatbots, which can simulate human interaction and provide instant responses to students' questions (Akram Mei Hasman et al., 2023). One example is Perplexity AI, which is capable of providing accurate information along with reliable references, making it suitable for supporting learning activities (Nuran et al., 2025). However, the use of AI chatbots in classroom learning is still limited, and there are concerns regarding the balance between technological benefits and educational values (Andika Isma et al., 2026). Therefore, it is necessary to optimize the use of AI chatbots as a learning tool without neglecting fundamental aspects of education (Usman & Faradina, 2025). Based on these problems and research gaps, this study aims to analyze the effectiveness of integrating Artificial Intelligence (AI)-based chatbots into study group learning to improve students' self-efficacy in renewable energy materials for grade 10 students at SMAIT Al-Fityah Pekanbaru. In addition, this study aims to examine the differences in self-efficacy between students who learn using AI chatbot-assisted study group learning and those who experience conventional learning methods.

2. Methodology

This study uses a quantitative approach with a quasi-experimental type and a nonequivalent control group design (Sugiyono, 2023). The research was carried out at SMAIT Al-Fityah Pekanbaru in the even semester of the 2025/2026 school year with a population of 46 students in class X. The research sample consisted of two classes determined based on homogeneity, namely the experimental class and the control class, with the determination of the group being carried out through a draw to avoid bias (Sugiyono, 2023). The experimental class was given treatment in the form of learning using Artificial Intelligence (AI)-based chatbots in study group learning, while the control class used conventional learning. In the experimental class, chatbots act as digital scaffolding that helps students understand the material through group discussions and providing direct feedback.

The research instrument is in the form of a self-efficacy questionnaire that measures the dimensions of magnitude, strength, and generality (Laily & Wahyuni, 2018). Questionnaires were given before and after treatment to find out changes in students' self-efficacy. The N-Gain values are then classified into high, medium, and low categories based on the criteria shown in Table 1.

Table 1. N-Gain Interpretation Criteria

Gain Score	Interpretation
$g > 0.70$	High
$0.70 > g > 0.30$	Medium
$g < 0.30$	Low

3. Results and Discussion

The learning process in this study showed differences in student engagement between the experimental and control classes. In the experimental class, learning was conducted using AI chatbot-assisted study group learning on renewable energy material, while the control class used conventional learning methods. During the learning activities, students in the experimental class were actively involved in group discussions and were supported by the use of an AI chatbot to enhance their understanding of the material. The chatbot was used by students to ask questions, search for information, and clarify concepts that were not yet understood, allowing them to receive immediate feedback during the learning process. In contrast, students in the control class tended to rely on teacher explanations and individual understanding without the assistance of AI, resulting in a less interactive learning environment. At the beginning of the learning process, students were first given a self-efficacy questionnaire before the treatment to determine their initial level of confidence in learning as shown in Figure 1.

Figure 1. Students completing the self-efficacy questionnaire before the learning treatment.

This activity also served as the initial data collection stage in this study. The learning activities were then carried out through several stages of study group learning, beginning with the teacher explaining the learning objectives and providing a brief introduction to the implementation of the learning activities. Students were subsequently divided into groups, followed by clarification of the learning objectives to ensure that each group clearly understood the tasks to be completed. After that, students were given the opportunity to work individually by utilizing an AI chatbot (Perplexity AI) as shown in Figure 2 and Figure 3.

Figure 2. Student interaction with AI chatbot (Perplexity AI) through prompt input during the learning process

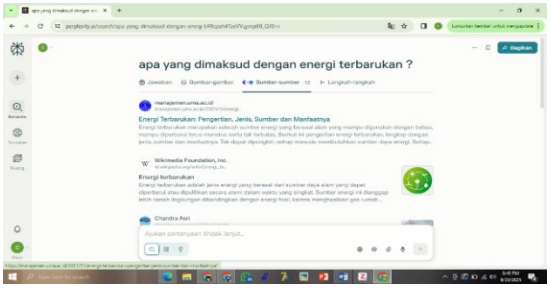

Figure 3. Chatbot response displaying answers and reference sources generated by Perplexity AI

Students actively interacted with the chatbot by entering questions in the prompt column and reviewing the responses along with the referenced sources provided by the system. This interaction enabled students to explore concepts more independently and verify the information obtained during the learning process. After that, they clarified their understanding before sharing their ideas within their groups. This was followed by group discussions in which students collaboratively discussed the material and solved the given problems. The results of the group discussions were then brought into class discussions as shown in Figure 4 , enabling students to exchange ideas and respond to each other's answers.

Toward the end of the learning process, students summarized the material through questioning, responding, and note-taking activities, followed by a follow-up stage to reinforce their understanding. Finally, after the learning activities were completed, students were given a self-efficacy questionnaire after the treatment, which functioned as the final data collection stage to measure the improvement in their self-efficacy.

Figure 4. Students presenting the results of group discussions during the learning process

Based on the data obtained from the pre- and post-questionnaires, an analysis was conducted to determine the extent of improvement in students' self-efficacy. The results showed that there was an increase in the self-efficacy of students in both the experimental class and the control class. This improvement was further analyzed using the N-Gain to evaluate the effectiveness of the treatment provided. The comparison of the N-Gain values of students' self-efficacy in each class is presented in Table 2.

Table 2. N-Gain of Students' Self-Efficacy

Dimensions of Self-Efficacy	Experimental Class		Control Class	
	N-Gain	Categories	N-Gain	Categories
Difficulty	0.63	Medium	0.34	Medium
Strength	0.53	Medium	0.30	Medium
Generalization	0.57	Medium	0,34	Medium
Average	0.57	Medium	0.32	Medium

Based on Table 2, the average N-Gain value in the experimental class of 0.57 was in the medium category and higher than the control class of 0.32. This shows that the use of AI chatbots in study group learning is more effective in increasing students' self-efficacy than conventional learning. To see the comparison of self-efficacy improvements in more detail in each dimension, the data is also presented in the form of a graph in Figure 5.

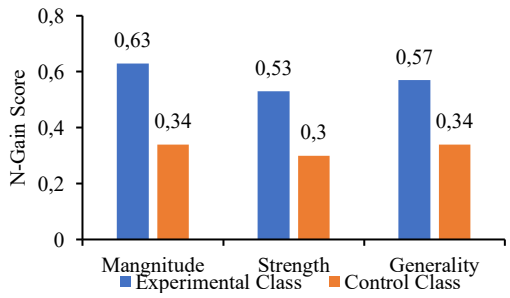

Figure 5. N-Gain of Self-Efficacy by Dimension

Based on the data presented in Figure 5, the improvemen in students' self-efficacy can be examined across three dimensions, namely magnitude, strength, and generality. In the magnitude dimension, the N-Gain value in the experimental class reached 0.63, which is higher than the control class at 0.34. This indicates that students in the experimental class demonstrated a better ability to deal with task difficulty. The use of AI chatbots supports this improvement by providing quick access to information and immediate feedback, which enhances students' confidence in completing challenging tasks. This finding is consistent with the concept that AI can function as a "peer apprentice" that supports collaborative learning processes and provides cognitive assistance during group interaction (Ng, 2026). This finding is in line with Akram Mei Hasman et al., (2023), who stated that AI-assisted learning can improve students' understanding. Wang (2026) also reported that the use of AI contributes to increasing students' confidence in learning.

In the strength dimension, the N-Gain value in the experimental class was 0.53 (medium category), while the control class was 0.30 (low category). This shows that AI chatbot-assisted learning has a greater influence on strengthening students' belief in their abilities. Interaction through chatbots combined with group discussions creates a more active and engaging learning environment, which supports the development of stronger self-confidence. This is consistent with previous findings that study group learning, as a form of collaborative learning, can enhance participants' knowledge and competence through structured interaction (Binongo, 2026). This is consistent with Suryana et al. (2022), who emphasized the importance of social interaction in learning. Faris Anwar et al., (2024) also found that collaborative learning can enhance students' confidence and participation.

In the generality dimension, the N-Gain value in the experimental class was 0.57, higher than the control class at 0.34. This indicates that students in the experimental class have a better ability to generalize their confidence across different learning situations. The integration of chatbot-based learning enables students to apply their understanding in various contexts, thereby improving flexibility in thinking. This is supported by Kamal et al. (2025), who highlighted the role of AI in adaptive learning. Michael Sitorus, (2023) also explained that AI can support contextual learning processes.

Overall, these findings indicate that the integration of AI chatbots in study group learning is more effective

in improving students' self-efficacy compared to conventional learning. This result is consistent with Gontina & Asyhar, (2023), who stated that AI can enhance interactive learning environments. Akram Mei Hasman et al., (2023) also found that chatbot-based learning improves both cognitive and affective aspects of students.

The Mechanism of AI Chatbot Features in Enhancing Self-Efficacy

Beyond the quantitative gains reported above, the mechanism through which the AI chatbot enhanced students' self-efficacy can be explained through its specific interactive features. Three features appeared particularly influential: (1) instant feedback, which allowed students to immediately verify whether their understanding of a concept was correct without waiting for teacher intervention; (2) supplementary explanations, in which the chatbot could reword or elaborate on a concept in simpler language when students' initial understanding was incomplete; and (3) real-time question-answering, which let students pose questions as they arose during discussion rather than saving them for a later, more intimidating, whole-class session. These features map closely onto Bandura's (1997) four sources of self-efficacy.

Instant feedback and successful independent problem-solving through the chatbot function as mastery experiences, the most influential source of self-efficacy, because each successfully resolved question becomes direct evidence to students that they are capable of understanding the material. Observing peers interact confidently with the chatbot and receive correct explanations also provides a form of vicarious experience, particularly during group discussions when students exchanged chatbot-verified information with one another. The chatbot's non-judgmental, always-available response style additionally reduces the social risk of asking questions in front of the class, which lowers the physiological and emotional arousal (e.g., anxiety, fear of embarrassment) that Bandura identified as an inhibiting source of self-efficacy for students who are hesitant or afraid of making mistakes.

Finally, the encouragement students received from teachers and peers to use the chatbot as a legitimate learning tool functioned as a form of verbal persuasion, reinforcing their belief that they were capable of mastering the material with proper support. This mechanism helps explain why the largest gain was observed in the magnitude dimension: repeated successful use of the chatbot to resolve difficulties directly built students' confidence in tackling tasks of increasing difficulty.

Comparison with Previous Studies

To situate these findings within the broader literature on AI-assisted learning, the results of this study were compared with several previous studies examining the use of AI chatbots or other AI-based technologies in learning. Akram Mei Hasman et al. (2023) implemented chatbot-based digital interactive media in a primary school science classroom and reported that classical mastery learning rose from 45% in the first learning cycle to 87.5% in the second cycle; although that study measured learning outcomes rather than self-efficacy directly, the substantial gain across two cycles is broadly consistent with the medium-to-strong improvement (N-Gain = 0.57) found in the present study, suggesting that chatbot-supported instruction tends to produce cumulative rather than one-off gains. Kamal et al. (2025), using a nonequivalent control group design similar to the present study, found that students taught with Gemini AI achieved a significantly higher mean achievement score than the conventional class, a pattern that parallels the present finding that the AI chatbot-assisted class outperformed the conventional class on every self-efficacy dimension.

Wang (2026), in a large-scale study of 744 university students, found that generative AI literacy improved academic achievement primarily through its positive effect on academic self-efficacy, an effect that was more pronounced among students with stronger critical thinking skills; this is consistent with the present study's finding that self-efficacy gains were most pronounced in the magnitude dimension, where task-level confidence is most directly tied to successful, verifiable AI-assisted problem solving. In contrast, Andika Isma et al. (2026), studying a hybrid AI chatbot model in a higher-education informatics program, found that chatbot use significantly improved the efficiency and quality of academic services but did not explicitly examine self-efficacy, suggesting that the confidence-building effect observed in the present study may be more salient among younger secondary students than among university students already accustomed to digital tools. Usman and Faradina (2025) reported that combining AI with a Lower Order Thinking (LOT) instructional stage produced a significantly higher posttest score for learning independence in the experimental class than in the control class, reinforcing the present conclusion that AI is most effective when embedded within a structured pedagogical sequence rather than used as a stand-alone tool. Ng (2026) proposed a conceptual model in which generative AI functions as a "Peer Apprentice" within collaborative idea construction, a role that closely mirrors how the chatbot in the present

study supported, rather than replaced, group discussion. Gontina and Asyhar (2023) similarly concluded that AI can strengthen interactive science and physics learning environments, while cautioning that its negative effects need to be anticipated so that its positive impact remains dominant, a caution that is directly relevant to the limitations discussed below. Taken together, the N-Gain obtained in this study is broadly consistent with, and in several respects more favorable than, the outcomes reported in these previous studies, most likely because the present design deliberately combined AI chatbot use with structured study group learning rather than relying on the chatbot as an isolated intervention, thereby simultaneously activating both the AI-assisted mastery experiences and the social sources of self-efficacy associated with collaborative learning.

Strengths and Limitations of AI Chatbot Use in Group Learning

Beyond its effectiveness in improving self-efficacy, the use of an AI chatbot within group learning carries both advantages and limitations with practical implications for teachers. Among its advantages, the chatbot provided students with easy and immediate access to information, removing the delay that would otherwise occur while waiting for teacher clarification and allowing group discussions to continue without interruption. It also appeared to increase student participation, since students who were previously reluctant to ask questions in front of the class were more willing to explore the chatbot individually before contributing to group discussion, effectively lowering the threshold for engagement.

However, several limitations should be considered. First, there is a risk that students become overly dependent on the chatbot for answers rather than developing their own reasoning and problem-solving strategies, which could undermine independent conceptual understanding in the long term. Second, because chatbot-generated responses are not always fully accurate or contextually appropriate, students without sufficient prior knowledge may struggle to critically evaluate the information they receive, potentially reinforcing misconceptions if answers are accepted uncritically. Third, the effectiveness of chatbot-assisted learning depends heavily on the clarity of students' prompts and their digital literacy skills, meaning that without adequate guidance, the benefits of the technology may not be evenly distributed among students. These findings carry practical implications for teachers intending to implement AI chatbots in classroom learning. Teachers are advised to maintain an active facilitating role by monitoring chatbot use, encouraging students to cross-check AI-generated information against other sources, and gradually reducing scaffolding, so that the AI chatbot functions as a supportive component of a structured learning design rather than a substitute for the teacher's role.

4. Conclusion

This study demonstrates that the integration of AI-based chatbots within study group learning represents an effective pedagogical approach to enhance students' self-efficacy in learning renewable energy concepts. The findings indicate that the effectiveness of this approach is not solely attributed to the use of technology, but to the synergistic interaction between collaborative learning processes and AI-supported scaffolding. In this context, the chatbot functions as a cognitive support system that facilitates immediate feedback, promotes independent exploration, and strengthens students' confidence through continuous interaction, which is consistent with the role of social interaction in learning. Technology-supported learning also contributes to the development of students' confidence. From a theoretical perspective, this study extends the application of social cognitive theory by highlighting that self-efficacy can be developed through hybrid learning environments that integrate human collaboration and artificial intelligence. The results suggest that self-efficacy is influenced not only by mastery experiences but also by structured guidance, real-time feedback, and technology-assisted learning support. Artificial intelligence can also support contextual and interactive learning processes.

Practically, this study provides important implications for educators, particularly in physics learning involving abstract materials. The use of AI chatbots can be implemented as a structured learning support within study group activities to facilitate conceptual understanding, guide inquiry processes, and enhance student engagement. This approach aligns with previous findings that AI-based learning tools can support interactive and adaptive learning environments, improve learning outcomes, and enhance interactive learning environments. Future research should focus on broader implementation across different subjects and educational levels, as well as investigating the long-term impact of AI-assisted collaborative learning on both cognitive and affective domains.

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