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Impact of AI-Blended Learning and AI-Personalized Learning on Undergraduate Biology Students' Attitude and Performance in Climate Change Education

Suleiman Sa'adu Matazu
Department of Science and Vocational Education, Faculty of Education and Extension Services, Usmanu Danfodiyo University, Sokoto Nigeria
Corresponding authors email:
saadu.matazu@udusok.edu.ng
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ABSTRACT

This study employed a quasi-experimental design to investigate the impact of AI-Blended Learning and AI-Personalized Learning on undergraduate biology students' attitudes and performance in climate change education. The research addressed two research questions and tests two corresponding null hypotheses. The population consists of 300 level under-graduate biology students at Federal University Gusau, with a sample size of 70 students selected through random sampling. Participants were divided into three groups; AI-Blended Learning (20 students), AI-Personalized Learning (20 students), and Traditional Classroom Instruction (30 students). The intervention lasted four weeks. AI-Blended Learning group used ChatGPT-3.5 alongside traditional classroom instruction, while the AI-Personalized Learning group solely relied on ChatGPT-3.5 for their instruction. Data were collected using two instruments; the Climate Change Attitude Assessment (CCAA) and the Climate Change Achievement Test (CCAT). Both CCAA and CCAT were validated by experts and have reliability coefficients of 0.84 and 0.82, respectively. Data collected were analyzed using mean and standard deviation for the research questions, and Analysis of Covariance (ANCOVA) tests for the null hypotheses at a significance level of 0.05. Findings revealed that AI-Blended Learning significantly improved students' attitudes and performance compared to AI-Personalized Learning and Traditional Classroom Instruction. It is recommended that, lecturers should adopt AI-Blended Learning with ChatGPT-3.5 to improve student engagement and learning outcomes in environmental education.

Keywords: AI-Blended Learning, ChatGPT, AI-Personalized Learning, Climate Change Education, Student Attitudes, performance

1. INTRODUCTION

The rapid advancement of artificial intelligence (AI) technologies has revolutionized educational practices, providing innovative approaches to teaching and learning. Among these, AI-Blended Learning and AI-Personalized Learning have emerged as significant methodologies that can potentially enhance student engagement and academic performance (Alshahrani, 2023; Chen et al., 2020). AI-Blended Learning integrates AI tools with traditional classroom instruction, offering a hybrid model that combines the strengths of both approaches (Park & Doo, 2024; Tong et al., 2022). Conversely, AI-Personalized Learning leverages AI algorithms to tailor educational content and experiences to individual student needs, promoting a more customized learning environment (Hwang et al.

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,2020).

Climate change education is an increasingly critical component of the biology curriculum, given the urgency of global environmental issues (Monroe et al., 2019). Traditional classroom instruction, often characterized by a one-size-fits-all approach, may not adequately address the diverse learning preferences and needs of students, potentially limiting their engagement and understanding of complex topics such as climate change (Anderson, 2012; Singh, 2021). Therefore, exploring the impact of AI-enhanced learning methods on students' attitudes and performance in climate change education is essential for developing more effective educational strategies.

Recent studies have highlighted the positive effects of AI-Blended and AI-Personalized Learning on various educational outcomes. For instance, Park and Doo (2024), Ismail et al. (2024), Tong et al. (2022) and Zawacki-Richter et al. (2019) reported that AI-Blended Learning environments could improve student motivation and conceptual understanding in science subjects. Similarly, research by Holmes et al. (2019) demonstrated that AI-Personalized Learning could significantly enhance academic performance by providing adaptive feedback and personalized learning pathways.

ChatGPT is a powerful language model Chatbot developed by OpenAI, a leading research organization focused on advancing artificial intelligence technologies. ChatGPT is capable of generating human-like text based on input. Chatbots are used in education to provide instant feedback, facilitate learning, and support administrative tasks (Okonkwo & Ade-Ibijola, 2021). These AI-driven tools like ChatGPT can simulate human conversations, making them valuable for tutoring, answering student queries, and creating interactive learning environments. Examples include AI-powered tutoring systems and virtual teaching assistants that enhance student engagement and learning outcomes (Chen et al., 2020). This study aims to investigate the impact of AI-Blended Learning and AI-Personalized Learning on undergraduate biology students' attitudes and performance in climate change education, compared to traditional classroom instruction.

1.1. Review of Related Literature

Artificial intelligence has progressively permeated various sectors, and education is no exception. AI in education encompasses a range of applications, from intelligent tutoring systems and automated grading to predictive analytics and personalized learning environments. AI technologies offer the potential to transform traditional educational practices by enhancing the personalization of learning experiences, optimizing administrative tasks, and providing data-driven insights for decision-making (Holmes et al., 2019; Ismail et al., 2024; Tong et al., 2022). According to Chen et al. (2020), AI-driven adaptive learning systems can adjust content delivery based on student performance and engagement, thereby supporting individualized learning paths and potentially improving educational outcomes.

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AI applications in education can broadly be categorized into three main areas: administrative support, instructional support, and student support. Administrative support involves automating routine tasks such as scheduling, attendance tracking, and grading, which can free up teachers to focus more on teaching and interacting with students (Sangheethaa & Korath, 2024; Zawacki-Richter et al., 2019). Instructional support includes AI-powered tools that assist teachers in creating and delivering content, such as intelligent tutoring systems and virtual teaching assistants (Ismail et al., 2024; Luckin et al., 2016). Finally, student support AI applications in education can broadly be categorized into three main areas: administrative support, instructional support, and student support. Administrative support involves automating routine tasks such as scheduling, attendance tracking, and grading, which can free up teachers to focus more on teaching and interacting with students (Sangheethaa & Korath, 2024; Zawacki-Richter et al., 2019). Instructional support includes AI-powered tools that assist teachers in creating and delivering content, such as intelligent tutoring systems and virtual teaching assistants (Ismail et al., 2024; Luckin et al., 2016). Finally, student support encompasses personalized learning environments that adapt to individual learners' needs, providing tailored feedback and resources to enhance the learning experience (Kulik & Fletcher, 2016).

Blended learning, which combines traditional face-to-face instruction with online learning activities, has been significantly enhanced by AI technologies. AI-blended learning environments leverage the capabilities of AI to create more interactive and personalized learning experiences (Alshahrani, 2023). In science education, AI-blended learning can facilitate the integration of virtual labs, simulations, and interactive tutorials, which can enhance students' conceptual understanding and engagement (Ismail et al., 2024). Research has shown that AI-blended learning can improve student outcomes in science education. For example, a study by Tong et al. (2022), Sangheethaa and Korath (2024), and Wu et al. (2010) found that students who participated in an AI-blended learning environment demonstrated higher levels of engagement and better academic performance compared to those in traditional classroom settings. The AI components, such as real-time feedback and adaptive learning pathways, enabled students to grasp complex scientific concepts more effectively and at their own pace.

Moreover, according to Wu et al. (2010), AI-blended learning can support collaborative learning and critical thinking skills, which are essential in science education. Through AI-powered discussion forums, peer assessment tools, and collaborative projects, students can engage in meaningful interactions with their peers and instructors, fostering a deeper understanding of scientific principles (Alshahrani, 2023; Hwang et al., 2020). The integration of AI in blended learning also

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allows for the continuous monitoring and assessment of student progress, enabling teachers to identify and address learning gaps promptly (Alshahrani, 2023; Sangheethaa & Korath, 2024; Tong et al., 2022).

AI-personalized learning approaches are designed to cater to the individual learning needs and preferences of students. These approaches utilize AI algorithms to analyze student data, such as learning behaviors, performance metrics, and engagement levels, to create customized learning experiences. The goal is to provide each student with the most appropriate resources, activities, and feedback to optimize their learning outcomes (Chen et al., 2020). One of the key benefits of AI-personalized learning is its ability to offer real-time adaptive feedback. For instance, intelligent tutoring systems can provide immediate feedback on student performance, helping learners understand their mistakes and correct them promptly (Magomadov, 2020; Woolf et al., 2013). This continuous and personalized feedback loop can enhance student motivation and self-efficacy, as they receive support that is tailored to their specific needs and progress.

AI-personalized learning approaches have been shown to be particularly effective in subjects that require a high degree of individualized instruction, such as mathematics and science. Studies have demonstrated that students in AI-personalized learning environments tend to perform better academically compared to those in traditional settings. For example, a study by Magomadov (2020) and Roschelle et al. (2016) found that students who used an AI-powered personalized learning platform for mathematics achieved significant gains in their test scores compared to a control group. Furthermore, AI-personalized learning can support the development of 21st-century skills, such as critical thinking, problem-solving, and self-directed learning. By providing learners with personalized learning paths and resources, AI can help students develop these essential skills in a more targeted and efficient manner (Luckin et al., 2016). The use of AI in personalized learning also promotes equity in education, as it can provide additional support to students who may be struggling or have diverse learning needs (Holmes et al., 2019).

Traditional classroom instruction in climate change education typically involves lectures, textbook readings, and standardized assessments. While this approach provides a foundational understanding of climate science, it may not fully engage students or address their diverse learning needs (Anderson, 2012). Traditional methods often rely on passive learning, where students are expected to absorb information without actively engaging with the content or applying their knowledge to real-world scenarios. Research has highlighted several limitations of traditional classroom instruction in climate change education. For example, Monroe et al. (2019) noted that traditional methods might not effectively convey the complexity and urgency of climate change, leading to a lack of student motivation and interest. Similarly, the one-size-fits-all approach may not cater for the diverse learning

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preferences of students, resulting in varying levels of understanding and engagement (Singh, 2021).

However, traditional classroom instruction remains an important component of climate change education, as it provides a structured learning environment and access to expert knowledge (Singh, 2021). Teachers can enhance traditional methods by incorporating interactive and experiential learning activities, such as field trips, experiments, and discussions, to make the content more relevant and engaging for students (Anderson, 2012; Matazu & Isma'il, 2023). The integration of AI technologies with traditional instruction can also address some of these limitations by providing personalized and adaptive learning experiences.

Educational interventions, such as AI-enhanced learning methods, have been shown to positively impact student attitudes and performance. AI-blended and AI-personalized learning approaches can create more engaging and effective learning experiences, leading to improved academic outcomes and student satisfaction (Alshahrani, 2023; Chen et al., 2020). These interventions can also influence students' attitudes towards the subject matter, increasing their interest and motivation to learn.

Studies have demonstrated that AI-enhanced learning environments can lead to higher levels of student engagement and achievement. For instance, Zawacki-Richter et al. (2019) and Wu et al. (2010) found that students in AI-blended learning environments reported greater satisfaction with their learning experiences and achieved better academic results compared to those in traditional settings. The interactive and personalized nature of AI-enhanced learning can make the content more accessible and relevant to students, fostering a positive attitude towards the subject.

Moreover, AI-personalized learning approaches can address individual learning needs and preferences, resulting in more equitable educational outcomes. Research by Holmes et al. (2019) indicates that students who receive personalized support through AI technologies are more likely to succeed academically and develop a positive attitude towards learning. This is particularly important in climate change education, where students may have varying levels of prior knowledge and interest.

1.2. Statement of the Problem

The growing recognition of the importance of climate change education has not translated into effective engagement of students to fully address their diverse learning needs within traditional classroom instruction. This inadequacy is particularly pronounced in undergraduate biology courses, where profound understanding of climate change is imperative. The one-size-fits-all approach of traditional classroom instruction may limit student motivation and attitudes towards complex environmental issues. Emerging AI-enhanced learning methods, such as AI-Blended Learning and AI-Personalized Learning, offer

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potential solutions by providing interactive and customized learning experiences. However, there is a lack of empirical research examining the effectiveness of these AI-based approaches compared to traditional instruction. Therefore, the main objective of this study is to investigate the impact of AI-Blended Learning and AI-Personalized Learning on undergraduate biology students' attitudes and performance in climate change education.

1.3. Research Questions

The study was guided by the following question;

- What are the effects of AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction on students' attitudes towards climate change?
- What are the effects of AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction on students' performance in climate change education?

1.4. Null Hypotheses

The following null hypotheses were formulated for the study;

- There is no significant difference in the mean scores of students' attitude towards climate change among AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction.

There is no significant difference in the mean performance scores of students in AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction in climate change education.

Methodology

This study employed a quasi-experimental design with a pretest-posttest control group design. The study included 70 undergraduate biology students from Federal University Gusau. The students were divided into three groups namely AI-Blended Learning (n=20), AI-Personalized Learning (n=20), and Traditional Classroom Instruction (n=30). The participants were assigned to one of the three instructional groups through random sampling from existing classes of 300-level Biological Science students at the university.

The participants in the AI-Blended Learning group combined traditional classroom instruction (face-to-face teaching) with AI-enhanced online activities that provide real-time feedback mechanisms to engage them to augment their understanding of climate change concepts. AI-Personalized Learning group experienced a fully AI-driven personalized learning environment. An intelligent tutoring system adapted content and activities based on individual engagement levels, offering personalized feedback and personalized learning paths. This group were only given the topics they will covered within the time frame of the research. Participants in both the AI-Blended Learning and AI-Personalized Learning groups used ChatGPT-3.5, a free AI developed by OpenAI, for the intervention. The participants in the Traditional Classroom Instruction group followed conventional classroom instruction. This involved a series of face-to-face lectures

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with no intervention. This group served as a control group for comparison.

A questionnaire tagged Climate Change Attitude Assessment (CCAA) was used to assess students' attitudes towards climate change across four dimensions, namely; awareness, concern, perceived importance, and willingness to take action. The CCAA was rated on a 4-point Likert scale. It was validated through expert review and pilot testing, with a reliability score of 0.85 using Cronbach's alpha. A mean score of 2.5 or above indicates a positive attitude towards climate change. Another instrument tagged Climate Change Achievement Test (CCAT) was constructed. The CCAT consisted of multiple-choice and short-answer questions designed to evaluate students' knowledge of climate change education. It was validated by experts. Reliability of CCAT was evaluated with Pearson Product-Moment Correlation, resulting in a coefficient of 0.82, by test-retest.

The climate change topics covered by all the groups were, Introduction to Climate Change, Causes of Climate Change, Impacts of Climate Change, Mitigation Strategies, Global and Local Perspectives on Climate change and Climate Change Policies and Actions. A week before the beginning of the intervention, student participants in all groups completed a pre-test using the CCAA and CCAT. After the four weeks' instructional period, the participants completed a post-test to measure changes in attitudes and performance. Data collected were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (Analysis of Covariance (ANCOVA)) at a significance level of 0.05, with post hoc tests specifying group differences. Statistical Package for Social Sciences (SPSS) version 23 was used for the analyses.

Results

Research Question One: What are the effects of AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction on students' attitudes towards climate change?

Table 1 revealed that, AI-Blended Learning resulted in a substantial increase in students' attitudes towards climate change (mean gain score = 32.41), higher than AI-Personalized Learning (mean gain score = 5.16) and Traditional Classroom Instruction (mean gain score = 3.94). AI-Personalized Learning also showed a higher gain compared to Traditional Classroom Instruction.

Null Hypothesis One ($H0_1$): There is no significant difference in the mean attitudinal scores of students towards climate change among AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction.

The ANCOVA results in Table 2a revealed significant effect of instructional groups (AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction) on students' posttest scores in attitudes towards climate change, while controlling for pretest scores, $F_{(2, 67)} = 144.050$, $p < .001$, $\eta^2 = 0.766$.

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Table 1: Mean scores of the instructional groups on students' attitudes towards climate change

Instructional Groups	N	Pretest		Posttest		Mean Gain Score
		Mean	SD	Mean	SD	
AI-Blended Learning	20	45.18	2.87	77.59	3.12	32.41
AI-Personalized Learning	20	46.89	3.05	52.05	2.94	5.16
Traditional Classroom Instruction	30	45.97	2.91	49.91	3.08	3.94

Table 2a: ANCOVA results on mean attitudinal scores among the three instructional groups

Source	Type II Sum of Square	df	Mean Square	F Value	Sig.	Partial Eta Squared
Corrected Model	1024.320	3	341.440	109.996	.000	0.766
Intercept	119.647	1	119.647	38.498	.000	0.575
Covariate (Pretest)	10.065	1	10.065	3.240	.076	0.097
Group	894.608	2	447.304	144.050	.000	0.681
Error	314.073	67	4.691			
Total	1368.713	71				
Corrected Total	1338.393	70				

Table 2b: Summary of Scheffé's Post Hoc Test for Attitudes Towards Climate Change

Treatments	AI-Blended Learning	AI-Personalized Learning	Traditional Classroom Instruction
AI-Blended Learning	-	27.25*	28.47*
AI-Personalized Learning	27.25*	-	5.22
Traditional Classroom Instruction	28.47*	5.22	-

* denotes pairs of groups that are significantly different ($p < 0.05$)

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Therefore, $H0_1$ is rejected, indicating a significant difference in the mean attitudinal scores of students towards climate change among the three instructional groups. To determine which specific groups differ, Scheffé's Post hoc test was conducted (see Table 2b).

The summary of Scheffé's post hoc test in Table 2b revealed that AI-Blended Learning significantly improved students' attitudes towards climate change compared to AI-Personalized Learning and Traditional Classroom Instruction ($p < 0.05$). No significant difference was found between AI-Personalized Learning and Traditional Classroom Instruction.

Research Question Two: What are the effects of AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction on students' performance in climate change education?

Table 3 revealed the effects of instructional methods on students' performance in climate change education were AI-Blended Learning substantially improved in posttest scores (Mean = 27.57, SD = 4.12), demonstrating a mean gain score of 11.69. AI-Personalized Learning (Mean = 16.50, SD = 3.75) and Traditional Classroom Instruction (Mean = 19.01, SD = 3.89) showed smaller improvements, with mean gain scores of 0.03 and 3.01, respectively.

Null Hypothesis Two ($H0_2$): There is no significant difference in the mean performance scores of students in AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction in climate change education.

The ANCOVA results in Table 4a revealed a significant effect of instructional groups on students' posttest scores, controlling for pretest scores, $F_{(2, 67)} = 42.281$, $p < 0.001$, $\eta^2 = 0.664$. On the basis of this, $H0_2$ was rejected, that there is a significant difference in the mean performance scores of students among AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction in climate change education. Thus, determine which specific groups differ, Scheffé's Post hoc test was conducted as shown in Table 2b.

The summary of Scheffe's post hoc test in Table 4b revealed that AI-Blended Learning significantly improved mean gain scores compared to AI-Personalized Learning (mean difference = 11.66, $p < 0.05$) and Traditional Classroom Instruction (mean difference = 8.68, $p < 0.05$). AI-Personalized Learning showed no significant difference compared to Traditional Classroom Instruction (mean difference = 2.98, $p > 0.05$).

DISCUSSION

The findings related to Research Question One and Null Hypothesis One, as indicated in Table 1, revealed that AI-Blended Learning demonstrated the most substantial increase in mean score from pre-test to post-test, indicating a positive impact on attitudes towards climate change. AI-Personalized Learning and Traditional Classroom Instruction also showed increases, though to a lesser extent.

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Table 3: Descriptive statistics for students' performance in climate change education

Instructional Groups	N	Pretest		Posttest		Mean Gain Score
		Mean	SD	Mean	SD	
AI-Blended Learning	20	15.88	4.12	27.57	4.12	11.69
AI-Personalized Learning	20	16.47	3.75	16.50	3.75	0.03
Traditional Classroom Instruction	30	16.00	3.89	19.01	3.89	3.01

Table 4a: ANOVA Results for Performance Scores in Climate Change Education

Source	Type II SS	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	362.454	3	120.818	37.279	<0.001	0.707
Intercept	87.576	1	87.576	27.018	<0.001	0.569
Covariate (Pre-test)	0.292	1	0.292	0.090	0.765	0.003
Group	274.586	2	137.293	42.281	<0.001	0.664
Error	149.153	67	2.228			
Total	1061.790	71				
Corrected Total	511.607	70				

Treatment	AI-Blended Learning	AI-Personalized Learning	Traditional Classroom Instruction
AI-Blended Learning	-	11.66*	8.68*
AI-Personalized Learning	11.66*	-	2.98
Traditional Classroom Instruction	8.68*	2.98	-

* denotes pairs of groups that are significantly different ($p < 0.05$)

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The significant difference in students' attitudes towards climate change among the three instructional groups, supported by the ANCOVA result (Table 2a), rejects the $H0_1$ that there is no significant difference in the mean attitudinal levels of students towards climate change among AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction. Post hoc analysis using the Scheffe's post hoc test (Table 2b) further showed AI-Blended Learning significantly differed from AI-Personalized Learning and Traditional Classroom Instruction in impacting attitudes towards climate change. This finding is consistent with studies by Smith (2020), who reported the potential of AI-Blended Learning in promoting positive environmental attitudes. AI-Blended Learning, utilizing ChatGPT-.3.5, can personalize learning experiences by adapting content and pacing to match students' learning styles and interests. This personalized approach may engage students more effectively with climate change issues, nurturing deeper understanding and positive attitudes.

Table 3 presented descriptive statistics for students' performance in climate change education across AI-Blended Learning, AI-Personalized Learning, and Traditional Classroom Instruction. AI-Blended Learning achieved the highest mean performance score, suggesting superior effectiveness compared to AI-Personalized Learning and Traditional Classroom Instruction. The standard deviations indicate moderate variability in scores for all groups. The significant difference in mean performance scores among the three instructional groups, as evidenced by the ANCOVA results (Table 4a), supports the rejection of the null hypothesis ($H0_2$). Scheffe's post hoc test (Table 4b) further clarified that AI -Blended Learning significantly outperformed AI-Personalized Learning and Traditional Classroom Instruction in impacting student performance. This stresses the effectiveness of ChatGPT-3.5 in AI-Blended Learning in improving knowledge and understanding of climate change concepts. It also underscores the potential of AI technologies like ChatGPT in enhancing educational learning outcomes, aligning with previous research by Brown and Jones (2021) and Park and Doo (2024) indicating that AI-Blended Learning, utilizing technologies such as ChatGPT, can improve student performance by providing personalized and adaptive learning experiences.

Conclusion

The findings of this study indicate that AI-Blended Learning, particularly when integrated with ChatGPT-3.5, significantly improved students' attitudes and performance in various aspects of climate change education compared to AI-Personalized Learning and Traditional Classroom Instruction. This could be attributed to the fact that, AI-Blended Learning combines the advantages of both online utilizations of ChatGPT-3.5 and traditional classroom instruction, offering flexibility and accessibility while maintaining teacher-student interaction. It may also cater to students' learning styles by adapting content and pacing to match their individual needs and preferences. These results indicated the effectiveness of ChatGPT in improving educational outcomes through teacher

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guidance, providing personalized learning experiences that engage students effectively with complex topics like climate change. Therefore, the study recommends the followings:

1. Higher education lecturers should integrate AI-Blended Learning, utilizing ChatGPT, alongside traditional classroom instruction to enhance student engagement and improve learning outcomes.
2. Students should actively utilize AI tools like ChatGPT to supplement their traditional classroom learning, especially for understanding complex topics. They should also provide feedback to their teachers to enhance the use of AI in education.
3. Researchers should conduct more studies to investigate the impact of AI-Blended Learning on students' learning outcomes, particularly in complex subjects.

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