Impact of AI-Supported Multimodal Learning Environments on EFL Students' Critical Thinking and Self-Regulation

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Abstract

This quasi-experimental study investigates the effect of AI-enhanced multimodal learning environments on improving the critical thinking and self-regulation abilities of English as a Foreign Language (EFL) students in a primary school in Shanxi Province, China. This study had 220 participants, categorized into experimental and control groups. The experimental group participated in learning activities utilizing AI tools like ChatGPT and multimodal resources, whilst the control group adhered to a conventional instructional method. Pre-tests and post-tests were conducted to assess variations in critical thinking and self-regulation. Statistical analysis revealed that students in AI-supported multimodal environments significantly outperformed their peers in critical thinking and self-regulation. These findings indicate that the incorporation of AI technologies in EFL primary education can significantly enhance higher-order thinking and autonomous learning skills. The study enhances the existing research on the efficacy of AI in educational environments and offers practical guidance for educators seeking to adopt AI-augmented learning methodologies in analogous scenarios.

Keywords: AI-Supported Learning, Multimodal Learning, Critical Thinking, Self-Regulation, EFL Primary Education

1. Introduction

The potential of Artificial Intelligence (AI) to personalize and adjust learning experiences has made it a hot topic for education, especially when it comes to improving English as a Foreign Language (EFL) instruction. Real-time feedback and customized support are provided by AI technologies like ChatGPT, which are essential for non-native speakers looking to advance their language proficiency (Li, 2024). AI makes it possible to move away from traditional teacher-centered methods and towards a more participatory, student-centered approach by analyzing data and providing personalized learning routes (Pendy, 2023). This change is particularly important in China, where being able to communicate in English is necessary for both professional and academic success (Çayır, 2023). To guarantee responsible AI applications, ethical issues such as data privacy and algorithm openness must be

addressed (Makarenko, 2024). All things considered, AI has the power to revolutionize EFL instruction by providing creative solutions that can greatly improve student results.

EFL instruction in China has always been based on teacher-centered approaches that prioritize rote memorization and grammar-translation strategies. The development of critical thinking and self-regulation abilities, which are essential for successful language learning, is frequently overlooked by this method (Hao & Razali, 2022; Jannah et al., 2021). Students who use critical thinking skills to analyze and synthesize information can engage with language more deeply (Sari et al., 2019). In the meantime, self-regulation fosters independence and lifelong learning by enabling students to set objectives, monitor their progress, and reflect on their experiences (Hao & Razali, 2022). Enhancing EFL education requires incorporating instructional practices that support the growing demand for English competence in China (Çayır, 2023). Learners can be better prepared for language use in real-world situations by implementing interactive, student-centered approaches (Yang & Wang, 2020).

The typical EFL curriculum in China limits students' capacity to acquire critical thinking and self-regulation abilities because it mostly focuses on teacher-centered methods. This strict framework frequently results in passive learning, in which students absorb knowledge without applying it to their own lives or critically analyzing their development (Li & Chen, 2018). Students thus find it difficult to use critical thinking and self-regulation techniques, both of which are necessary for independent study and scholastic achievement (Gan et al., 2023). These abilities might be developed by changing the EFL curriculum to incorporate more learner-centered strategies, which would ultimately improve academic results (Abdullah et al., 2020).

In China, using AI technologies in EFL training is becoming more and more seen as a solution to the problems with conventional teacher-centered methods. By offering individualized guidance and real-time feedback, ChatGPT and other AI tools enable interactive, dialogue-based learning that can improve students' self-regulation abilities (Qiao, 2023). Students can ask questions, get clarification on topics, and get quick responses while interacting with AI, which encourages deeper engagement with the material (Moybeka, 2023). Moreover, AI-enabled multimodal learning environments that include language games, diagrams, and videos accommodate various learning preferences and improve student engagement while encouraging self-regulation (Arabshahi, 2024). These settings encourage autonomous, critical engagement with the language by giving students the freedom to select materials that support their learning objectives (Jin et al., 2023). All things considered, integrating AI into EFL instruction improves the learning process and gives students the tools they need to succeed in both their academic and professional endeavors.

Recent studies (Jin et al., 2023; Qiao, 2023) highlight the growing potential of AI-supported multimodal learning environments in EFL classrooms, focusing on self-regulated learning and language proficiency. Jin et al. (2023) emphasize that such environments cater to diverse learning styles, while Qiao (2023) underlines their impact on fostering autonomy and self-regulation. Integrating these insights would provide stronger grounding for this study's focus on critical thinking and self-regulation. Students can gain a lot from the usage of AI-supported learning environments in EFL instruction. Studies indicate that artificial intelligence (AI) systems offer more prompt and thorough feedback than conventional techniques, enabling students to evaluate and modify their performance instantly. Students are urged to examine and improve their language use, which fosters a stronger critical engagement with the content as a result of the quick feedback. AI-supported environments also encourage critical thinking and meaningful language engagement, which further encourage active participation. Because these environments offer a wide range of multimodal resources, students are also better able to self-regulate their learning by selecting resources that best fit their requirements. As a result, learning environments enhanced by AI not only boost student engagement but also aid in the development of critical cognitive and metacognitive abilities required for language learning.

Even with the encouraging developments in AI-supported learning, there is still a dearth of empirical studies on how AI-supported learning affects the cognitive and metacognitive abilities of EFL students, especially in China. The majority of research has concentrated on how AI might enhance language competence; its effects on critical thinking and self-regulation abilities have received less attention (Moybeka, 2023; Alghamdy, 2023). Higher-order thinking abilities are essential for both language

acquisition and academic performance, therefore this discrepancy is substantial (Spector & Ma, 2019). Research on how AI explicitly improves these skills is limited, however metacognitive training has been demonstrated to help EFL students employ critical thinking and self-regulation to improve writing performance (Teng, 2021). To properly comprehend AI's function in building critical cognitive skills in EFL learners, this gap must be filled.

This study builds on earlier findings by Gan et al. (2023) and Sari et al. (2019), which explored the intersection of AI-supported environments and cognitive skills. By examining how these tools specifically impact critical thinking and self-regulation, the research addresses a gap in understanding their role in higher-order cognitive skill development. By examining the effects of AI-supported multimodal learning environments on the growth of critical thinking and self-regulation in EFL students at a primary school in Shanxi Province, China, this study seeks to close that gap. The results of students who engage in AI-supported environments will be compared to those of students who get traditional teacher-centered instruction in this quasi-experimental study. This study attempts to give educators useful ideas for incorporating AI into their teaching techniques by presenting actual data on how well AI fosters critical thinking and self-regulation. The results will add to the expanding body of knowledge on artificial intelligence in education and offer practitioners and researchers insightful direction. In particular, this project will investigate how self-regulation and critical thinking are improved by AI tools, enabling educators to better use these tools to promote student learning. The findings will also have applications in the field of curriculum design, providing evidence-based suggestions for incorporating AI into EFL training to encourage independent learning and higher-order thinking.

2. Purpose and Objectives

This study examines how English as Foreign Language (EFL) students' cognitive and metacognitive abilities are affected by AI-supported multimodal learning settings. The main emphasis is on critical thinking and self-regulation, which are crucial abilities for successful language acquisition but are frequently disregarded in conventional, teacher-centered training (Tahereh et al., 2021). Finding novel ways to improve English proficiency is crucial as it is a need for success in China's academic and professional arenas (Li, 2022).

The primary objective of the study is to assess how well AI-supported multimodal learning environments assist EFL students in developing their critical thinking and self-regulation skills. It will contrast the learning outcomes of students in AI-enhanced learning environments with those getting conventional, teacher-directed teaching using a quasi-experimental design. The findings will provide useful information for EFL teachers who are interested in implementing AI technology, as well as contribute to the current conversation on AI's place in education, specifically in language learning. The following are the study's particular objectives:

1. Assessing the effects of multimodal learning with AI support on critical thinking abilities.

Students who use critical thinking are better able to evaluate many interpretations, examine linguistic patterns, and interact closely with texts (Nasution & Afrianti, 2022). In comparison to conventional approaches, this study will evaluate if AI technologies such as ChatGPT, which provide real-time interaction and personalised feedback, can dramatically improve critical thinking.

2. Evaluating how AI-supported learning affects the ability to self-regulate.

Setting objectives for learning, keeping track of advancement, and thinking back on the process of learning are all components of self-regulation (Schunk & Zimmerman, 2023). With its interactive and multimodal resources, AI-supported environments may promote the growth of these abilities by giving users more freedom and chances for introspection. This study will investigate whether students in AI-supported environments exhibit better self-regulation than their counterparts in conventional classes.

3. Examining the connection between overall academic achievement and AI-supported learning.

This research will investigate whether AI-supported multimodal learning environments enhance language competence and academic accomplishment overall, going beyond critical thinking and self-regulation. The study will provide light on how AI tools improve language and cognitive learning outcomes by comparing pre- and post-test scores.

4. Offering empirical proof of how well AI tools work to encourage higher-order thinking in EFL instruction.

Although AI tools are increasingly being used in a variety of educational settings, there is not much empirical data on how well they work to develop higher-order thinking abilities like self-control and critical thinking, especially in Chinese EFL situations. By providing data-driven insights into how AI may improve these critical skills, our study seeks to close that gap.

By focussing on these goals, the study will add to the growing body of knowledge about artificial intelligence in education and provide useful advice for English as a Foreign Language (EFL) teachers who want to use AI-supported learning environments. The results will have an impact on curriculum development, instructional strategies, and policy formulation. They will offer evidence-based recommendations on how to use AI technology to help EFL learners develop critical thinking, self-control, and academic performance.

3. Methods

3.1 Research Design

This study used a quasi-experimental design to investigate how AI-supported multimodal learning environments affect EFL students' critical thinking and self-regulation abilities. Because it permits the comparison of two groups—an experimental group and a control group—without necessitating random assignment, which is sometimes impracticable in real-world educational environments, the quasi-experimental technique was chosen (Maciejewski, 2020). In this study, traditional teacher-led training was given to the control group, while the experimental group participated in an AI-supported learning environment. The primary distinction between the two groups was the style of instruction, as they both adhered to the identical EFL curriculum.

3.2 Participants

In this study, 220 sixth graders from a primary school in Shanxi Province, China, participated. Due to their enrolment in EFL classes as required by the institution, these students were chosen by convenience sampling. Two equal groups of students were formed: a control group (n = 110) and an experimental group (n = 110). To guarantee comparability, the participants were matched according to important demographic variables such as age, gender, and previous English proficiency. Crucially, the groups' pre-test results for self-regulation and critical thinking did not differ significantly from one another.

3.3 Instruments

The Watson-Glaser Critical Thinking Appraisal (WGCTA) and the Self-Regulation Questionnaire (SRQ) were the two main tools utilized to assess the study's results. Both tools are widely used in educational research and have a great track record of validity and reliability.

The standardized Watson-Glaser Critical Thinking Appraisal (WGCTA) measures five essential aspects of critical thinking: deduction, interpretation, inference, appraisal of arguments, and recognition of assumptions (Watson & Glaser, 1991). The Watson-Glaser Critical Thinking Appraisal (WGCTA) was chosen for its proven ability to assess nuanced cognitive processes, particularly within educational contexts involving non-native English learners (Watson & Glaser, 1991). Additionally, scoring rubrics were standardized to ensure consistency across evaluators. The exam consists of forty multiple-choice questions and should take about sixty minutes to finish. To track changes in students' critical thinking abilities during the intervention, the WGCTA was given as a pre-and post-test in this study.

With an emphasis on goal setting, self-monitoring, and reflection, the Self-Regulation Questionnaire (SRQ) is a self-report instrument that assesses students' capacity for self-regulation in the learning process (Brown et al., 1999). Higher scores indicate stronger self-regulation abilities. The 63 items are scored on a 5-point Likert scale. The SRQ was used, like the WGCTA, to measure improvements in self-regulation throughout a 10-week intervention. It was given as a pre-and post-test.

3.4 Procedure

The study took place over 10 weeks during the fall semester. Both the experimental and control groups followed the same EFL curriculum, aligned with the primary school's language learning objectives. The key difference between the groups was the mode of instruction: the experimental group participated in an AI-supported multimodal learning environment, while the control group received traditional teacher-directed instruction (see Figure 1).

Students in the experimental group used AI tools like ChatGPT for dialogue-based learning activities. These activities involved interactive exercises where students asked questions, clarified concepts, and received real-time feedback on their language use. In addition to AI tools, the experimental group accessed a variety of multimodal resources, such as videos, diagrams, and interactive language games. These resources catered to different learning styles and allowed students to engage with the material in diverse ways. The AI tools also provided personalized feedback, enabling students to monitor their progress and adjust their learning strategies. For the experimental group, interactive activities were designed to align with Bloom's taxonomy, ensuring a systematic approach to cognitive development.

In contrast, the control group followed a more traditional, teacher-centered approach to EFL instruction. The teacher delivered lectures, assigned reading materials, and led classroom discussions. Although students in the control group completed the same language learning tasks as the experimental group, they did so without the use of AI tools or multimodal resources. Feedback was provided by the teacher either during class discussions or through written comments on assignments. Unlike the experimental group, the control group did not receive personalized, real-time feedback.

Figure 1. *Research Procedure*
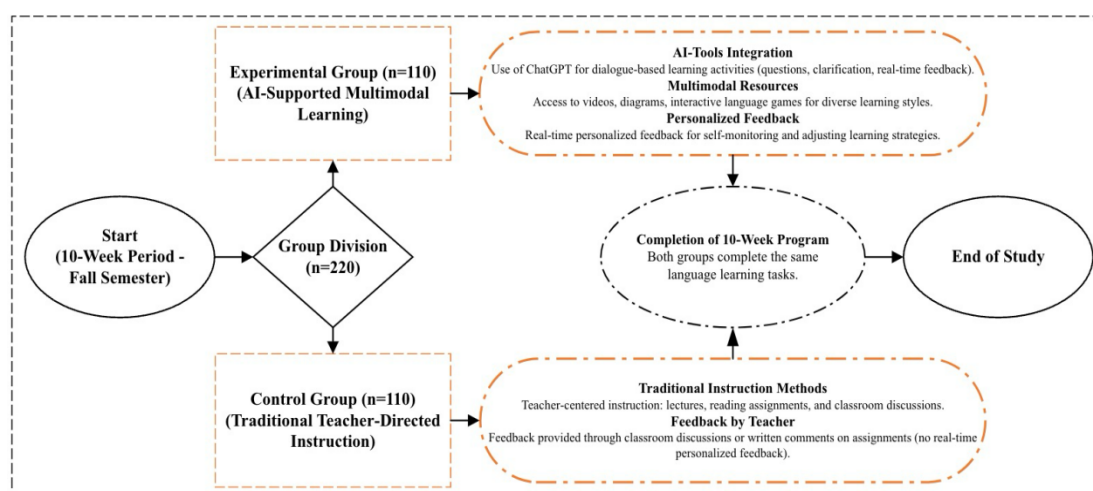
3.5 Data Collection

Three times were data collected: at the beginning of the semester (pre-test), halfway through the intervention (mid-test), and after the 10 weeks (post-test). The first week's pre-test set baselines for critical thinking and self-control. After five weeks, students were given a mid-test to monitor their development, and in the last week, they were given a post-test to gauge the overall effect of the AI-supported learning environment on these skills.

Reflective journals and student interviews were used to collect qualitative data in addition to these quantitative measurements. Twenty students were chosen at random from each group to participate in

interviews. During the interviews, the students discussed their opinions on the feedback they had received, their experiences with the learning environment, and their self-regulation techniques. Additional information about how students tracked their progress and modified their strategies throughout the intervention was provided by the reflective diaries.

3.6 Data Analysis

With the use of SPSS (Statistical Package for the Social Sciences), the quantitative data gathered from the pre-and post-tests was examined. Tests using paired samples evaluated changes within each group, and tests using independent samples examined the variations between the experimental and control groups. An analysis of covariance (ANCOVA) was used to adjust for any pre-test differences, which made it possible to measure the influence of the AI-supported learning environment on critical thinking and self-regulation with greater accuracy.

Thematic analysis was performed on student interviews and reflective diary data. There were recurring themes found, including how students saw the classroom, how they used AI technologies, and how they handled self-control. Together with the quantitative data, these qualitative insights provided a more thorough understanding of the impacts of the AI-supported learning environment.

3.7 Ethical Considerations

The primary school's ethics committee gave the study its ethical approval. Each participant gave written consent before participation, after being fully informed about the goal of the study. Throughout the study, confidentiality was maintained, and students were free to leave at any moment without incurring any consequences.

1. Results and Discussion

Results of the study show that EFL students in the experimental group had considerable improvements in their critical thinking and self-regulation skills thanks to the AI-supported multimodal learning environment. The results of the WGCTA and SRQ are grouped quantitatively, and the qualitative information obtained from semi-structured interviews with experimental group members is divided into two categories.

4.1 Quantitative Findings

The paired-sample t-test results in Table 1 revealed a significant improvement in the critical thinking skills of students in the experimental group. Their mean pre-test score of 24.5 increased to 31.2 in the post-test ($t = 3.21$, $p < 0.05$). In contrast, the control group showed only a modest increase, from 24.3 in the pre-test to 26.0 in the post-test ($t = 0.92$, $p > 0.05$). These findings suggest that the AI-supported multimodal learning environment significantly enhanced students' critical thinking about language use, while traditional teacher-centered instruction did not yield comparable improvement.

Table 1. *Pre- and Post-Test Scores for Critical Thinking*

| Group	Pre-Test Critical Thinking	Post-Test Critical Thinking	t-Value
Experimental	24.5	31.2	3.21
Control	24.3	26.0	0.92

A similar pattern was observed for self-regulation in Table 2. In the experimental group, the mean pre-test score of 27.8 rose to 35.6 in the post-test ($t = 2.89$, $p < 0.05$). The control group showed only a slight increase, from 28.1 to 29.4 ($t = 0.87$, $p > 0.05$). These results indicate that the AI-supported learning environment not only improved critical thinking but also fostered self-regulation. Students in the experimental group were more likely to set goals, monitor their progress, and reflect on their learning compared to their peers in the control group.

Table 2. *Pre- and Post-Test Scores for Self-Regulation*

Group	Pre-Test Self-Regulation	Post-Test Self-Regulation	t-Value
Experimental	27.8	35.6	2.89
Control	28.1	29.4	0.87

Figure 2 Bar graph visualizes comparing the pre-and post-test scores of critical thinking and self-regulation scores of the control and experimental groups. ANCOVA results further confirmed that the experimental group had significantly higher post-test scores for critical thinking and self-regulation than the control group, even after controlling for pre-test differences (F = 4.15, p < 0.05 for critical thinking; F = 3.87, p < 0.05 for self-regulation). These findings reinforce the effectiveness of the AI-supported multimodal learning environment in promoting higher-order thinking skills and autonomous learning behaviors in EFL students.

Figure 2. *Pre- and Post-Test Scores for Critical Thinking and Delf-Regulation for Both Groups*
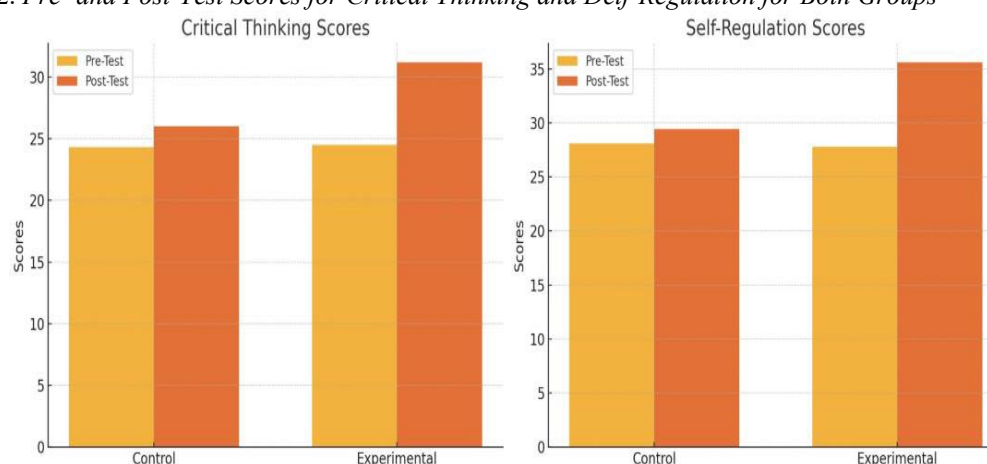
4.2 Qualitative Findings

Students' experiences with the AI-supported learning environment were better-understood thanks to the qualitative information gleaned from their reflection journals and interviews. Students in the experimental group emphasized how real-time feedback and critical thinking prompted by ChatGPT, one AI tool, in particular, promoted deeper usage of the language. According to a student, "*I enjoy using ChatGPT because it forces me to consider why and how to correct my incorrect answers. It has the effect of having a tutor who is constantly on hand for assistance.*" Numerous students had similar views, praising the ability to engage in dialogue-based learning and the tailored comments they received.

The multimodal resources proved to be beneficial for pupils in the experimental group when it came to self-regulation. As elucidated by a student, "*I was able to select resources according to my areas of need and the videos and interactive exercises improved my understanding of the material. My sense of control over my education increased as a result.*" Many students talked about how AI technologies helped them set goals, track their progress, and modify their learning tactics as necessary. This feeling of autonomy emerged often.

As opposed to this, pupils in the control group stated that their education was more passive. "*In a regular classroom, we merely listen to the teacher and complete the tasks that are found in the book. My perception of my learning has decreased, and it is not as participatory*," said one student. Based on these results, the learning environment with AI helps improve critical thinking and self-regulation while also creating a greater sense of control over the learning process.

4.3 Discussion

The results of this investigation align with earlier studies on the benefits of AI-assisted learning environments in developing higher-order cognitive abilities and encouraging self-directed learning practices (Alghamdy, 2023; Qiao, 2023). The experimental group showed noteworthy enhancements in

critical thinking and self-regulation, suggesting that AI tools like ChatGPT can be beneficial for EFL students by offering individualized feedback and interactive learning experiences (Pendy, 2023; Moybeka, 2023). These resources support students in developing self-regulated learning strategies, such as goal setting and reflection, as well as critical thinking about how they use language (Gan, Liu, & Nang, 2023).

This study's emphasis on the joint effects of AI and multimodal learning environments is one of its main contributions. Although prior studies have looked at the advantages of AI tools and multimodal resources independently (Hao & Razali, 2022; Abdullah et al., 2020), this study shows that combining the two can increase student learning results even more (Çayır, 2023). The AI-supported environment accommodated diverse learning preferences by providing an array of multimodal resources, so enabling students to interact with the content in a manner that best fits their needs. Because students were free to choose the materials that best suited their learning objectives, this flexibility not only improved their language comprehension but also encouraged self-regulation (Jin et al., 2023).

Notwithstanding these encouraging results, the study also points out certain difficulties with AI-supported learning environments. A minor portion of the experimental group's pupils voiced doubts over the validity of ChatGPT's input, despite the majority of them reporting favorable encounters with AI tools. "*Sometimes the feedback was confusing, and I was not sure if it was correct,*" said one student. This implies that even when AI technologies are a great help, instructor supervision is still required to guarantee that students receive correct and insightful feedback (Entong, 2023; Arabshahi, 2024). Some students in the experimental group reported difficulty interpreting AI-generated feedback without teacher guidance. This highlights the importance of a hybrid approach, where AI tools complement but do not entirely replace traditional instruction (Entong, 2023).

2. Conclusion and Implications

The study's findings offer compelling proof that AI-supported multimodal learning environments can help EFL students considerably increase their critical thinking and self-regulation. Enhancing language learning using AI tools like ChatGPT has many advantages, such as more student autonomy, interactive learning possibilities, and personalized feedback. These benefits are especially significant in EFL settings, where the development of higher-order thinking abilities and independent study habits is essential for sustained language proficiency.

For EFL educators, these findings have significant ramifications. Firstly, they draw attention to how AI tools might enhance conventional teaching strategies and encourage students to actively engage with course materials. Teachers can provide personalized feedback and support, often unfeasible in conventional settings. With the help of this tailored feedback, students may evaluate their performance and modify their learning tactics in real-time, which is essential for the growth of both critical thinking and self-control.

Second, learning may be made more dynamic and interesting by utilizing multimodal resources in AI-supported environments. This method takes into account the diverse learning styles of pupils, enabling them to select the materials that best suit their objectives and develop their critical thinking and self-control. Diagrams and films, for example, may be helpful for visual learners, whereas language activities may be more enjoyable for auditory learners. Diverse materials provide for a more tailored learning experience and better address the needs of each learner.

This study highlights for policymakers the value of funding AI innovations and the infrastructure required to facilitate language acquisition. It is crucial to provide educators with the knowledge and tools they need to successfully incorporate AI capabilities as they become more widely available. Promoting AI-driven learning environments in the classroom involves providing professional development opportunities for educators to learn how to use technologies like ChatGPT and making sure schools have the technology infrastructure they need.

Policymakers should prioritize setting rules for the moral and responsible application of AI in education. AI has the potential to revolutionize language acquisition, but issues need to be resolved, including data

privacy, algorithmic bias, and the accuracy of AI-produced feedback. Clear rules are helpful to reduce these risks and guarantee that AI techniques are used to optimise student advantages.

Additional research is required to explore AI's long-term implications on student outcomes, even if this study provides insightful information about how AI-supported learning settings affect critical thinking and self-regulation. Future research should examine how different AI tool types can be modified to fit the demands of a wide range of learners, as well as the scalability of AI interventions in many educational situations. One possible avenue for research could be to determine whether AI tools work the same for kids with different levels of language ability or if some AI tools work better for particular language abilities like speaking or comprehension during reading.

Prospective investigations ought to additionally tackle plausible obstacles and constraints of AI-augmented learning environments, including those pertaining to digital literacy, accessibility, and educator preparation. By addressing these challenges, educators and legislators should ensure that AI tools are used to optimise their potential benefits for language learners.

In conclusion, by offering useful information to scholars and practitioners alike, this study adds to the expanding corpus of research on artificial intelligence in education. The study provides insightful advice for educators on utilizing AI tools to promote student learning by examining how they can improve critical thinking and self-regulation. In addition, the results have significant ramifications for curriculum development, teaching strategies, and policy formation. They provide empirically supported suggestions for incorporating AI into EFL training to encourage higher-order thinking and independent learning behaviors.

Acknowledgment

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