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A Study on Students' Critical Thinking and 5C Competencies Using AI-Powered English Teaching Software

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Abstract: This study aims to investigate the impact of integrating AI-enhanced English learning software into bilingual instructional practices on junior high school students' critical thinking and 5C competencies. A quasi-experimental research design was adopted in this study. The participants consisted of 50 junior high school students ranging from seventh to ninth grade. The experimental group (n = 24) engaged in bilingual learning using Cool English, while the control group (n = 26) received instruction through traditional Cool English teaching videos. The intervention lasted for three weeks. Pretests and posttests were administered, and the collected data were analyzed using independent samples t-tests. The results indicated that the experimental group demonstrated significantly superior performance compared to the control group in both critical thinking and 5C competencies. The effect sizes were above the medium level, with a particularly large effect observed in the dimension of post-intervention cognitive strategy performance. These findings suggest that the use of AI-enhanced instructional software effectively promotes the development of students' critical thinking and 5C competencies.

Keywords: Artificial Intelligence, Cool English, Bilingual Teaching, Critical Thinking, 5C Competencies

1. Introduction

In recent years, with the rapid development of digital technology, artificial intelligence (AI) has gradually become an important trend in education. Through real-time feedback and interactive mechanisms, AI can provide personalized learning support, promote higher-order thinking and metacognitive development (Yue Yim, 2024). In language learning, chatbots can also offer low-pressure opportunities for repeated practice and feedback, thereby improving learning outcomes (Torres & Kahveci, 2025). With the rise of competency-based education, critical thinking and the 5C competencies have become core abilities, and related studies indicate that they can effectively enhance learning performance (Kolstø et al., 2024; Gorucu et al., 2025). In bilingual education contexts, students are required to learn across languages, making their motivation and cognitive processes even more crucial (Zang & Bai, 2025). However, there is still a lack of empirical evidence regarding whether integrating AI into the "Bilingual Learning Companion Program" can further promote critical thinking and 5C competencies. Therefore, this study adopts a quasi-experimental design to investigate the impact of AI-based English learning tools (Cool English) on junior high school students. Through pre- and post-tests and statistical analysis, the study aims to examine instructional effectiveness and contribute empirical evidence to the integration of AI in bilingual education.

2. Method

This study targeted seventh- to ninth-grade students participating in the Ministry of Education's Bilingual Learning Program in Taiwan. A total of 50 students were recruited, including 24 students in the experimental group (14 males and 10 females) and 26 students in the control group (11 males and 15 females). A quasi-experimental design was employed. The experimental group adopted an AI-enhanced bilingual instructional model that integrated the Whisper speech recognition system and the Cool English AI conversation agent, while

the control group received traditional teacher-centered instruction. Data were collected through pretests and posttests using the “Online Learning Critical Thinking Tendency Scale” and the “5C Competency Tendency Scale.” Both instruments were established and validated measures with satisfactory reliability and validity. Therefore, this study focused on examining the differences between the experimental and control groups in overall critical thinking and 5C competencies (including cooperation, communication, critical thinking, creativity, and computational thinking). The instructional intervention lasted for three weeks, with two class sessions per week, each lasting 45 minutes. All instruction was conducted online via Microsoft Teams. Data were analyzed using SPSS statistical software. Independent samples t-tests and one-way analysis of variance (ANOVA) were employed to examine instructional effectiveness and the influence of background variables.

3. Results and Discussion

Independent samples t-tests were conducted on the pretest data. The results revealed that the experimental group scored significantly higher than the control group in critical judgment, critical thinking disposition, and overall performance. Cohen’s d values ranged from medium to relatively large effect sizes, indicating that certain differences in baseline abilities already existed between the two groups prior to the intervention, as shown in *Table 1*. *Table 2.* presents the results of the independent samples t-tests conducted after three weeks of AI-assisted instruction. The posttest findings demonstrated that the experimental group continued to significantly outperform the control group across the aforementioned dimensions. Moreover, Cohen’s d values remained at a medium level, suggesting that AI tools exerted a stable and substantively meaningful positive effect on students’ learning outcomes. In the analysis of the 5C competency dimensions, the experimental group showed superior performance compared to the control group in creativity, problem-solving, teamwork, and communication coordination. Notably, post-intervention cognitive awareness disposition reached a highly significant difference with a large effect size. These results indicate that AI’s real-time feedback and interactive mechanisms contributed to enhancing students’ ability to monitor and regulate their own learning processes, as illustrated in *Table 3*. Furthermore, one-way analysis of variance (ANOVA) results revealed that group membership had a significant effect on critical thinking disposition and overall competency performance.

Table 1. Independent Samples t-Test Results for Pretest Differences Between the Experimental and Control Groups

Dimension	Experimental Group (*N* = 24)		Control Group (*N* = 26)		*t*	*d*
	M	*SD*	*M*	*SD*		
Critical Judgment	3.97	0.82	3.43	0.59	2.67*	0.76
Critical Thinking Disposition	4.01	0.81	3.58	0.65	2.12*	0.59
Overall	3.99	0.76	3.49	0.58	2.59*	0.74

**p < 0.05*

Table 2. Independent Samples t-Test Results for Posttest Differences Between the Experimental and Control Groups

Dimension	Experimental Group (N = 24)		Control Group (N = 26)		*t*	*d*
	M	*SD*	*M*	*SD*		
Critical Judgment	4.01	0.85	3.57	0.80	1.90	0.53
Critical Thinking Disposition	4.10	0.64	3.64	0.78	2.24*	0.64
Overall	4.05	0.73	3.60	0.76	2.11*	0.60

**p < 0.05*

Table 3. Independent Samples t-Test Results for Posttest Differences in 5C Competencies Between the Experimental and Control Groups

Dimension	Experimental Group (N = 24)		Control Group (N = 26)		*t*	*d*
	M	*SD*	*M*	*SD*		
Creativity Disposition	3.93	0.80	3.48	0.98	1.77	0.50
Problem-Solving Disposition	3.98	0.73	3.55	0.76	2.00	0.58
Metacognitive Awareness Disposition	3.93	0.74	3.35	0.55	3.14**	0.90
Teamwork Disposition	3.96	0.79	3.52	0.78	1.96	0.56
Communication and Coordination Disposition	4.04	0.74	3.70	0.77	1.60	0.45
5C Competency Disposition	3.97	0.63	3.61	0.73	1.83	0.53

**p < 0.05 **p < 0.01*

4. Conclusion and Suggestion

Based on the empirical findings of this study, the integration of artificial intelligence into bilingual learning companion instruction demonstrates positive potential in enhancing junior high school students' critical thinking and 5C competencies. Although the experimental group showed some initial advantages in the pretest, after three weeks of AI-assisted instruction, significant improvements were observed in critical thinking, overall competencies, and 5C abilities—particularly in metacognitive awareness, which reached a large effect size. This suggests that AI's real-time feedback and interactive dialogue effectively support self-monitoring and strategy adjustment, thereby strengthening higher-order thinking and learning awareness. Moderate effects were also found in creativity, problem-solving, collaboration, and communication, indicating that AI contributes to the holistic development of multiple competencies. Accordingly, it is recommended that bilingual courses appropriately incorporate AI as a supportive tool, integrating real-time feedback and contextualized task design to enhance self-directed learning and reflective abilities, while also strengthening teachers' AI literacy to optimize instructional integration. Future research is encouraged to extend the duration of interventions, expand sample sizes, and employ methods such as ANCOVA or mixed designs to control for pretest differences for more precise evaluation. Additionally, incorporating qualitative data such as interviews and behavioral observations would allow for deeper exploration of students' cognitive and affective changes in AI-assisted learning contexts. Overall, this study supports the use of AI as an innovative instructional approach in bilingual education, with significant educational value in promoting students' cognitive development, collaboration, and self-regulation.

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