JURNAL EDUSCIENCE (JES)
p-ISSN : 2303 - 355X | e-ISSN : 2685 - 2217
PUBLISHED BY : LPPM of UNIVERSITAS LABUHANBATU

Project-Based Learning with AI-Integration to Foster Critical Thinking Skills and Self-Efficacy of Pre-Service Teachers

Dahrul Aman Harahap[1], Muhammad Faizin[2], Vinsensia Anisa Citta Erydani[3], Sri Lestari[4], Desi Surlitasari Dewi[5], Mega Aulia Ardhi[6]

[1]Department of Education Management, Universitas Riau Kepulauan, Indonesia
[2]Department of Primary Education, Universitas Pendidikan Muhammadiyah Sorong, Indonesia
[3] Department of Management, STIE BPD Jateng, Indonesia
[4]Department of Primary Education, Universitas PGRI Madiun, Indonesia
[5,6]Department of English Education, Universitas Riau Kepulauan, Indonesia
*Email: amandahrul@gmail.com

ARTICLE INFO

Keywords:
Project-based learning
Artificial intelligence
Critical thinking
Self-efficacy
Pre-service teachers

ABSTRACT

Purpose – This study aimed to evaluate the usefulness of Project-Based Learning (PjBL) combined with artificial intelligence (AI) tools in enhancing pre-service teachers' critical thinking and self-efficacy inside an instructional design course.

Methodology – A pre-experimental one-group pretest-posttest design was applied. The study involved 46 pre-service teachers engaged in an instructional design course at a private university in Indonesia, chosen using purposive sampling. Two instruments were used: a 25-item critical thinking questionnaire and a 10-item self-efficacy scale. Normality tests were conducted, followed by paired-sample t-tests to determine differences between pre-test and post-test scores.

Findings – The findings showed a statistically significant improvement in both critical thinking ($t = -116.464$, $p < .001$) and self-efficacy ($t = -56.328$, $p < .001$) after the AI-supported PBL intervention. The normality assumptions were met, and the effect size was notably strong for both variables. These results suggest that incorporating AI technologies into project-based learning can significantly improve pre-service teachers' cognitive and emotional preparedness for future teaching practices.

Contribution – This study contributes to the teacher education literature by providing empirical evidence for the integration of AI technologies in project-based learning, promoting critical thinking and self-efficacy. It offers practical insights for instructional designers and educators seeking to equip future teachers with the competencies required in technologically rich educational environments.

Received 05 July 2025; Received in revised form 15 July 2025; Accepted 21 October 2025
Jurnal Eduscience (JES) Volume 12 No. 5 (2025)
Available online 30 October 2025

INTRODUCTION

In recent years, the educational environment has undergone a substantial upheaval due to the rapid integration of technology and artificial intelligence (AI) into teaching methodologies. These developments have not only affected the methods of knowledge delivery but also redefined the skills anticipated of 21st-century learners (Owan et al., 2023). Self-efficacy and critical thinking are widely recognized as essential competencies for academic and professional achievement (Crogman & Trebeau Crogman, 2018; Dewi, 2015; Meletiadou, 2022; Panigrahi et al., 2021). Higher education institutions are tasked with providing pre-service teachers and educational professionals with cognitive and affective abilities (Huang, 2023; Lyublinskaya & Kaplon-Schilis, 2022). Consequently, educators are currently investigating innovative pedagogical frameworks, such as Project-Based Learning (PBL), particularly when enhanced by AI tools, to develop these crucial skills (Huang, 2021; Said et al., 2023; Tantrarungroj & Suwannatthachote, 2012).

Project-based learning (PjBL) is a student-centered pedagogical approach that enables learners to gain knowledge and skills through active engagement in real-world projects (Lim et al., 2023). It is generally recognized to promote autonomy and learner motivation (Huang, 2021; Miller, 2013; Musliadi et al., 2024). The incorporation of AI tools into Project-Based Learning (PjBL) environments provides individualized learning trajectories, automates feedback, and facilitates the execution of complex tasks (Azamatova et al., 2023; Williams et al., 2023). Instruments like ChatGPT, Canva, Quillionz, and Kahoot facilitate planning, content creation, visual design, and formative evaluation, thereby enhancing student engagement and learning efficacy (Bachtiar, 2025; Kim, 2024).

On the other hand, self-efficacy refers to an individual's confidence in their capacity to successfully execute a task (Bandura, 1985; Irie, 2021). In academic environments, individuals with high self-efficacy are more likely to persist despite difficulties, engage thoroughly in learning activities, and achieve superior results (Nusrat et al., 2022; Qobilovna, 2023). Research demonstrates that student-centered pedagogies, such as Project-Based Learning (PBL), can enhance learners' self-efficacy. The approach enables the students to assume responsibility for their education, collaborate effectively, and obtain regular feedback (Grant, 2011). When Project-Based Learning (PjBL) is augmented by artificial intelligence, students may experience enhanced confidence because digital tools can simplify tasks and foster learner autonomy (Zawacki-Richter et al., 2019).

Another important aspect of learning is critical thinking. It is defined as intentional and self-regulated judgment that facilitates interpretation, analysis, assessment, and conclusion (Zhang, 2023). It is increasingly required in academic and professional environments. Conventional lecture-based teaching frequently fails to cultivate higher-order thinking skills (Dewi et al., 2023). PjBL provides students with the cognitive framework necessary for problem-solving, data evaluation, and the formulation of evidence-based conclusions (Chistyakov et al., 2023). Numerous studies indicate that Project-Based Learning (PjBL) enhances critical thinking abilities through the reflective practices (Chistyakov et al., 2023; Cort et al., 2021; Damayanti, 2023; Sutrisno, 2025). Furthermore, the utilization of AI can improve the scaffolding and formative feedback systems that can foster students' critical reasoning and decision-making skills (Davy Tsz Kit et al., 2022; George, 2023; Kundu & Bej, 2025)

Despite the growing body of literature on PjBL and its benefits in education, a lack of empirical research persists, particularly in the quantitative examination of the effectiveness of AI-assisted PjBL in developing both self-efficacy and critical thinking skills among higher education students, especially in instructional design or education-related courses. Most studies tend to examine either one variable or use qualitative approaches such as classroom observations, student reflections, or thematic analysis of portfolios (Lim et al., 2023; Miller, 2013; Zhussupova & Shadiev, 2023). Moreover, few studies integrate AI tools meaningfully into the PjBL framework, even though these tools are increasingly being adopted in university-level classrooms. This gap highlights the need to understand the extent to which AI-supported PjBL actually influences measurable student outcomes.

A further issue is the insufficient emphasis on the interrelatedness of self-efficacy and critical thinking abilities. While both are vital qualities for learners, particularly those training to become educators, they are frequently studied in isolation. Research suggests that self-efficacy may moderate the impact of instructional design on cognitive outcomes, such as critical thinking (Zimmerman, 2002). Consequently, examining both constructs within a singular intervention can yield a more comprehensive understanding of the effects of instructional innovations on learners.

Moreover, although research in engineering, computer science, and business education has examined AI-integrated learning environments (such as AI tutoring systems and adaptive learning platforms), there is a paucity of studies within education faculties that train future teachers, curriculum developers, or instructional media specialists. These students must cultivate their critical and emotional competencies while also learning to exemplify and nurture these skills in their future classrooms. Consequently, assessing the influence of novel learning methodologies in this setting is both opportune and crucial.

Empirical evidence indicates that while AI-supported learning has been examined across diverse domains (Song & Song, 2023; Jin et al., 2023; Tantrarungroj & Suwannatthachote, 2012; Chistyakov et al., 2023; Zhussupova & Shadiev, 2023), the majority of these studies predominantly focus on cognitive outcomes, depend on qualitative data, or lack relevance to teacher education. This study examines explicitly pre-service teachers in Indonesia, employing a quantitative approach to assess self-efficacy and critical thinking concurrently.

This urgency is evident in Indonesian higher education classrooms, where initial observations in instructional design courses suggest that students often lack self-confidence in executing complex tasks and exhibit limited higher-order thinking when tasked with evaluating or designing learning materials. This signifies a genuine necessity for pedagogical strategies that can concurrently enhance both affective (self-efficacy) and cognitive (critical thinking) competencies.

This study's contribution is threefold: (1) it offers empirical validation in the underexplored domain of teacher education in Indonesia, (2) it concurrently examines two critical yet frequently analyzed constructs in isolation, and (3) it utilizes a quantitative pretest-posttest design, which remains relatively uncommon in this discipline (Pratama et al., 2025; Zhussupova & Shadiev, 2023).

In summary, this study fills the research gap by addressing the dual focus on self-efficacy and critical thinking in AI-supported PjBL, particularly in Indonesian higher education settings. It provides new empirical evidence to guide instructional design and future teacher training.

Thus, grounded in this context, the following research questions are the focus of this study:

1. To what extent does PjBL with AI-integration affect the self-efficacy of pre-service teachers?
2. To what extent does PjBL with AI-integration affect the critical thinking skills of pre-service teachers?

METHODOLOGY

Research Design

A quantitative one-group pre-test and post-test approach was employed to examine the impact of Project-Based Learning with AI integration on the self-efficacy and critical thinking abilities of higher education students. This design facilitated the measurement of changes in both variables following the adoption of the intervention. Nonetheless, it is crucial to recognize that this design has constraints, notably the lack of a control group. In the absence of a comparison group, it is challenging to attribute observed enhancements exclusively to the intervention, as exogenous factors such as historical events or maturation may also influence the outcomes. This study should be viewed as an exploratory endeavor to investigate the potential of AI-integrated project-based learning in higher education. This strategy was selected due to contextual limitations and the primary objective of obtaining preliminary empirical insights. Future studies should employ more rigorous experimental designs with control groups to substantiate causal claims.

Participant

Forty-six pre-service teachers enrolled in the Instructional Design course at a private institution in Indonesia constituted the participants. The participants were selected using purposive sampling, as they were directly involved in project-based activities that necessitated the use of AI tools for instructional design tasks. All students volunteered willingly and were apprised of the research aims. Despite the sample's modest size and confinement to a single institution, it was deemed sufficient for the objectives of this preliminary study. This study aimed to investigate the feasibility and efficacy of incorporating AI into Project-Based Learning (PjBL) within a specific instructional context, rather than generalizing the results to other higher education environments. However, the restricted participant count and the intentional sampling technique limit the generalizability of the findings, necessitating cautious interpretation.

Data Collection

This research included two tools to assess students' self-efficacy and critical thinking abilities. Before the primary study, both instruments underwent validation through a pilot test with 30 students who were not participating in the primary research and were enrolled in a different course within the same faculty. The initial tool was a self-efficacy questionnaire modified from Bandura's Self-Efficacy for Learning Form. The assessment consisted of 20 items, each evaluated on a five-point Likert scale, with ratings ranging from 1 (strongly disagree) to 5 (strongly agree). The instrument's validity was assessed via item-total correlation analysis. The results show that all items exhibited correlation coefficients over 0.30. The reliability test was examined by using Cronbach's alpha, which produced a value of 0.88. It indicates a reasonable degree of internal consistency. The second instrument was a critical thinking skills assessment (Facione). It comprises 25 multiple-choice questions that address essential characteristics like analysis, inference, explanation, and evaluation. The validity of the test items was evaluated using item discrimination and difficulty indices. All items meet the acceptable criteria for a valid instrument (discrimination > 0.30 and difficulty between 0.40 and 0.70). The Kuder-Richardson Formula 20 (KR-20) was employed to evaluate the test's reliability. The result coefficient is 0.81, which means it is a reliable instrument.

Procedure of Intervention

The intervention occurred over eight sessions in a course on instructional design for pre-service teachers. The project adhered to a systematic Project-Based Learning (PjBL) framework, incorporating Artificial Intelligence (AI) tools, to enhance students' critical thinking and self-efficacy. During the initial session, the lecturer presented the course objectives, elucidated the concept and phases of Project-Based Learning (PjBL), and discussed the function of AI technologies in facilitating the learning process. Students further undertook pre-tests on critical thinking and self-efficacy. In sessions two to seven, students collaborated in small groups to formulate a comprehensive teaching and learning process by choosing a specific instructional approach, strategy, or technique (e.g., inquiry-based learning, cooperative learning, flipped classroom). They examined learner traits, established learning objectives, selected relevant materials, outlined learning activities, and identified evaluation procedures. AI tools, including ChatGPT, Canva AI, and Grammarly, were utilized to facilitate brainstorming, generate instructional content, organize lesson plans, and enhance instructional papers. The speaker offered continuous guidance, demonstrating the ethical and practical use of AI tools. Students participated in peer criticism and self-reflection at each stage to assess their design choices and progress in learning. During the eighth session, each group showcased its instructional design project, articulating the rationale behind its selected methodologies and illustrating how AI tools facilitated its decision-making process. Following the lectures, students took post-tests to assess their critical thinking and self-efficacy. This intervention aimed to encourage active participation, enhance instructional design proficiency, and foster 21st-century skills in pre-service teachers by incorporating AI in a collaborative, project-based setting. To enhance methodological clarity, Table 1 provides an overview of the intervention flow, emphasizing the principal activities, employed AI tools, and the desired abilities throughout the eight sessions.

Table 1. Overview of Intervention Procedure (Session 1–8)

Session	Activities	AI Tools Used	Targeted Skills
1	Introduction to PjBL, AI tools, research briefing, pre-test	–	Orientation, baseline measurement
2	Group formation, topic selection, brainstorming ideas	ChatGPT	Idea generation, collaboration
3	Analysis of learner needs & objectives formulation	ChatGPT, Grammarly	Analytical reasoning, planning
4	Selection of materials & instructional strategies	Canva AI, ChatGPT	Decision-making, creativity
5	Drafting lesson activities and assessments	ChatGPT, Grammarly	Problem-solving, organization
6	Refinement of draft, peer feedback sessions	Grammarly, Canva AI	Critical evaluation, reflection
7	Finalization of instructional design project	ChatGPT, Canva AI	Synthesis, communication
8	Project presentation & post-test	–	Presentation skills, self-efficacy, and critical thinking

Data Analysis

The data gathered in this study were examined quantitatively by descriptive and inferential statistical methods. Before conducting the primary analysis, all data were initially examined for completeness and accuracy. Descriptive statistics, encompassing means, standard deviations, and percentage distributions, were employed to summarize the students' self-efficacy and critical thinking scores in both the pre-test and post-test phases. This provided a preliminary assessment of students' performance and the overarching patterns in their learning outcomes following the implementation of Project-Based Learning with AI integration. To assess the intervention's impact more rigorously, paired-sample t-tests were used to compare the mean scores of students' self-efficacy and critical thinking skills before and during the adoption of the AI-integrated PjBL model. This statistical method was selected as it effectively identifies significant changes between two related data sets obtained from the same participants. The significance level (α) was established at 0.05 to ascertain statistical significance. Before doing the t-tests, the normality assumptions were assessed using the Shapiro-Wilk test. The results confirmed the applicability of parametric tests by demonstrating that the data met the criteria for a normal distribution.

Furthermore, to assess the magnitude of change between the pre-test and post-test scores, effect sizes (Cohen's d) were calculated. All statistical analyses were performed with IBM SPSS Statistics version 26. The emphasis on paired t-tests was intentional, considering the one-group pre-test post-test design. The researchers acknowledge that further analyses, such as ANCOVA, subgroup analysis (e.g., by gender or prior digital literacy), or longitudinal tracking, could yield more profound insights in future studies. The current study was essentially a preliminary investigation, and subsequent research should broaden the analytical scope to enhance the robustness of the findings.

FINDINGS

Project-Based Learning with AI-Integration to Foster Critical Thinking Skills

Prior to executing the paired sample t-test to evaluate variations in students' critical thinking scores before and after the intervention, a normality test was conducted to confirm that the data met the parametric assumptions. The normality test confirmed that the critical thinking scores were normally distributed, with Kolmogorov–Smirnov ($p = .200$) and Shapiro–Wilk ($p = .232$) for the pre-test, and Kolmogorov–Smirnov ($p = .200$) and Shapiro–Wilk ($p = .137$) for the post-test, all above the .05 threshold.

Table 2. Summary of Critical Thinking Scores (Pre- and Post-test)

Measure	Pre-test Mean	Post-test Mean	Mean Difference	Std. Deviation	t-value	p-value	Effect Size (Cohen's d)
Critical Thinking	62.15	77.35	-15.20	0.89	-116.46	< .001	3.80 (very large)

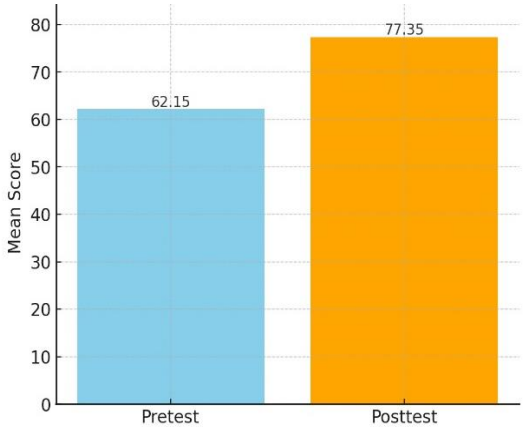

Figure 1. Comparison of Pre-test and Post-test Critical Thinking Scores

The paired samples t-test indicated a substantial increase in students' critical thinking scores after the intervention ($t = -116.46$, $p < .001$). On average, students improved by 15.20 points with a very large effect size (Cohen's $d = 3.80$). This consistent improvement across participants ($SD = 0.89$) suggests that the approach was broadly practical.

These findings resonate with previous studies, such as Tantrarungroj & Suwannatthachote (2012), who reported that project-based learning with digital tools significantly enhanced critical thinking among pre-service teachers. The integration of AI tools in the present study appears to amplify this effect by providing timely feedback, scaffolding, and cognitive support, which aligns with evidence that AI can act as a scaffold for higher-order reasoning (Davy Tsz Kit et al., 2022).

Project-Based Learning with AI-Integration to Foster Self-Efficacy

Similarly, the self-efficacy scores were normally distributed, as indicated by the Kolmogorov–Smirnov test ($p = .200$) and the Shapiro–Wilk test ($p = .177$) for the pre-test, and the Kolmogorov–Smirnov test ($p = .200$) and the Shapiro–Wilk test ($p = .238$) for the post-test.

Table 3. Summary of Self-Efficacy Scores (Pre- and Post-test)

Measure	Pre-test Mean	Post-test Mean	Mean Difference	Std. Deviation	t-value	p-value	Effect Size (Cohen's d)
Self-Efficacy	68.42	74.75	-6.33	0.76	-56.33	< .001	2.50 (very large)

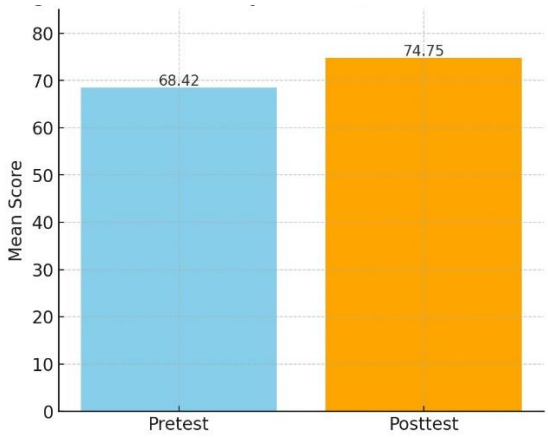

Figure 2. Comparison of Pre-test and Post-test Self-Efficacy Scores

The pre-test findings indicated a Kolmogorov–Smirnov significance value of 0.200 and a Shapiro–Wilk value of 0.177. The post-test findings revealed significant values of .200 (Kolmogorov–Smirnov) and .238 (Shapiro–Wilk). Given that all p-values exceed the alpha level of .05, the data for both the pre-test and post-test can be regarded as regularly distributed. It means that the data were normal. Consequently, a paired sample t-test was conducted for further investigation. The paired samples t-test revealed a significant improvement in students' self-efficacy after the intervention ($t = -56.33$, $p < .001$). Students' self-efficacy increased by an average of 6.33 points with a very large effect size (Cohen's $d = 2.50$).

DISCUSSION

This study's findings demonstrate that Project-Based Learning (PjBL) combined with AI tools can enhance critical thinking abilities and self-efficacy in higher education students enrolled in instructional design courses. These results align with the shifting demands of 21st-century education, where students are required not only to comprehend subject matter but also to exhibit critical thinking (Owan et al., 2023). In comparison to prior studies, the extent of improvement noted in this study aligns with Lim et al. (2023), who similarly identified learning benefits with PjBL in history instruction, but with a more moderate impact size. Conversely, Tantrarungroj & Suwannatthachote (2012) indicated that PjBL augmented pre-service teachers' self-efficacy and TPACK. However, the enhancement was not as significant as shown in the current study. This suggests that incorporating AI techniques enhances the efficacy of PjBL beyond conventional digital interventions.

In PjBL, such activities align with core components of critical thinking, as defined by Southworth (2022), which include identifying problems, formulating hypotheses, and evaluating arguments. Students entrusted with creating lesson plans or instructional media using AI tools, such as ChatGPT, Canva, and Kahoot, must examine intricate inputs, synthesize diverse concepts, and make strategic design decisions that stimulate higher-order cognitive processes. These tasks stimulate metacognitive regulation and reasoning, which Thornhill-Miller et al. (2023) recognize as essential attributes of critical thinkers. The incorporation of AI tools may have enhanced cognitive engagement through prompt assistance. These tools serve as cognitive scaffolds (Davy Tsz Kit et al., 2022), enabling students to utilize cognitive resources for planning, evaluation, and reflection. Those cognitive resources are essential elements of critical thinking (Zhang, 2023). The interactive characteristics of AI-driven applications can also promote real-time problem-solving, iterative enhancement, and user feedback. This method reflects Facione & Facione's (2008) critical thinking model in which learners are prompted to enhance their cognition through reasoning. The minimal variability in score disparities among participants suggests that the intervention was effective across diverse learner profiles. This reinforces that Project-based Learning (PjBL) with AI integration is both successful and accommodates specific learner

requirements. The findings align with Sutrisno (2025), who illustrated that PjBL enhanced students' critical thinking in science education.

The study also found an improvement in students' self-efficacy levels following their involvement in AI-assisted project-based learning. Self-efficacy is cultivated through mastery experiences, social modeling, and constructive feedback that are integral components of the PjBL paradigm. Students engaged in intricate projects acquired direct experience in strategizing and implementing significant educational material. It reinforces their confidence in their capacity to accomplish academic assignments. This supports the idea that when learners effectively engage in demanding tasks, they cultivate self-efficacy, particularly when these tasks are genuine and purpose-driven (Demirtaş & Mumcu, 2021; Scherer et al., 2018). The AI technologies incorporated into the project workflow offered supplementary support that potentially alleviated students' worries and enhanced their confidence. For example, systems like ChatGPT enable students to autonomously generate ideas or obtain clarification, thereby diminishing their reliance on instructors and fostering a sense of independence. Likewise, design tools such as Canva and presentation applications like Mentimeter empowered students to produce outputs of professional caliber, potentially augmenting their self-perception as capable future educators. This substantiates the notion that favorable results achieved using accessible techniques may serve as vicarious experiences, thereby enhancing efficacy beliefs (Tas, 2016).

Moreover, the project's organized framework and the opportunity to reflect and refine based on feedback likely strengthened pupils' sense of progress and improvement. This corresponds with prior studies indicating that student-centered, feedback-intensive environments enhance self-efficacy (Grant & Bolin, 2016; Ruelens, 2019). The little standard deviation in score improvements suggests a widespread perception of empowerment among the participants. In contrast to the findings of Tantrarungroj & Suwannatthachote (2012), which indicated moderate increases in self-efficacy, this study reveals more substantial and consistent improvements, likely attributable to the supplementary scaffolding offered by AI tools that alleviated anxiety and enhanced students' confidence in managing complex tasks.

The Indonesian higher education context introduces further complexity to these findings. Numerous colleges in Indonesia face challenges, including inconsistent digital infrastructure, inadequate AI proficiency among educators, and varying levels of student preparedness for technology-enhanced learning. The use of AI technologies in PjBL enhanced individual competencies and offered a pragmatic solution to national difficulties in cultivating digitally literate future educators. These findings are particularly relevant to the Merdeka Belajar policy, which prioritizes student-centered learning, digital innovation, and engagement in real-world tasks. This study demonstrates that AI-assisted Project-Based Learning (PjBL) can enhance critical thinking and self-efficacy, suggesting its potential to address digital readiness deficiencies among teacher candidates and align with broader educational changes in Indonesia.

This study's findings contribute to the existing research on AI-assisted learning settings, which has drawn on quantitative evidence from the educational sector (Pratama et al., 2025; Zhussupova & Shadiev, 2023). According to Zimmerman (2002), self-efficacy may serve as a motivating basis that facilitates the utilization of intricate cognitive abilities such as critical thinking. Consequently, AI-integrated Project-Based Learning provides a comprehensive method for pre-service teachers. The results indicate that lecturers in education faculties should contemplate implementing PjBL frameworks augmented with AI tools, particularly in instructional design courses.

Nonetheless, various methodological constraints must be recognized. The study utilized a one-group pre-test–post-test design lacking a control group, which limits causal inference and suggests that variables outside of the intervention may have influenced the reported improvements. The limited sample size (n = 46) from a single private university in Indonesia restricts the applicability of the findings to other higher education settings, particularly public institutions or diverse locations with varying degrees of digital preparedness. The study exclusively concentrated on short-term results, neglecting the examination of long-term retention of critical thinking and self-efficacy. Subsequent research should employ more rigorous experimental designs,

incorporate larger and more diverse populations, and investigate longitudinal effects to enhance the validity of the conclusions.

CONCLUSION

This research investigated the influence of Project-Based Learning (PjBL) combined with Artificial Intelligence (AI) tools on pre-service teachers' critical thinking and self-efficacy in an instructional design course. The results indicated a statistically significant enhancement in both critical thinking and self-efficacy scores post-intervention. The mean elevation in post-test scores suggests that incorporating AI into project-based assignments can enhance learners' higher-order cognitive skills and confidence in their capabilities. The uniform enhancement among participants underscores the efficacy of integrating creative pedagogy with emerging technology in teacher education. These findings underscore the efficacy of PjBL-AI as a significant pedagogical method for equipping pre-service teachers with the abilities necessary for 21st-century education. Future studies may investigate the enduring impacts and relevance of this approach across other educational settings and fields.

REFERENCES

Azamatova, A., Bekeyeva, N., Zhaxylikova, K., Sarbassova, A., & Ilyassova, N. (2023). The Effect of Using Artificial Intelligence and Digital Learning Tools Based on a Project-Based Learning Approach in Foreign Language Teaching on Students' Success and Motivation. *International Journal of Education in Mathematics, Science and Technology*, *11*(6), 1458–1475. https://doi.org/10.46328/ijemst.3712

Bachtiar, B. (2025). Preparing citizens for the future of digital literacy and AI: With a focus on Indonesian EFL teachers. *Digital Citizenship and the Future of AI Engagement, Ethics, and Privacy*, 405–440. https://doi.org/10.4018/979-8-3693-9015-3.ch015

Bandura, A. (1985). *Prentice-Hall series in social learning theory. Social foundations of thought and action: A social cognitive theory*. Prentice-Hall, Inc.

Chistyakov, A. A., Zhdanov, S. P., Avdeeva, E. L., Dyadichenko, E. A., Kunitsyna, M. L., & Yagudina, R. I. (2023). Exploring the characteristics and effectiveness of project-based learning for science and STEAM education. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(5). https://doi.org/10.29333/EJMSTE/13128

Cort, C., Nussbaum, M., Harcha, J., Alvares, D., & Felipe, L. (2021). Promoting critical thinking in an online, project-based course. *Computers in Human*, *119*(106705), 1–19.

Crogman, H., & Trebeau Crogman, M. (2018). Modified generated question learning, and its classroom implementation and assessment. *Cogent Education*, *5*(1). https://doi.org/10.1080/2331186X.2018.1459340

Damayanti et al. (2023). Strategi Pembelajaran Project Based Learning (Pjbl). *Jurnal Pendidikan Sosial Dan Humaniora*, *2*(2), 706–719. https://publisherqu.com/index.php/pediaqu

Davy Tsz Kit, N. G., Luo, W., Chan, H. M. Y., & Chu, S. K. W. (2022). Using digital story writing as a pedagogy to develop AI literacy among primary students. *Computers and Education: Artificial Intelligence*, *3*(October 2021), 100054. https://doi.org/10.1016/j.caeai.2022.100054

Demirtaş, B., & Mumcu, F. (2021). Pre-Service Teachers' Perceptions of ICT and TPACK Competencies. *Acta Educationis Generalis*, *11*(2), 60–82. https://doi.org/10.2478/atd-2021-0013

Dewi, D. S. (2015). Corrective Feedback in Class. *Anglo-Saxon*, *8*, 1–12.

Dewi, D. S., Waloyo, E., & Ria, T. N. (2023). The Impact of Technology-Based Learning on Students' Affective, Behavioral, and Cognitive Engagement in EFL Higher Education. *UNNES-TEFLIN National Conference (Vol. 5, Pp. 167-179).*, 167–179. https://proceeding.unnes.ac.id/utnc/article/view/2607

Facione, N. C., & Facione, P. A. (2008). Critical Thinking and Clinical Reasoning in the Health Sciences. In *Journal of Professional Issues in Engineering Education and Practice* (Vol. 8, Issue July).

George, A. S. (2023). Preparing Students for an AI-Driven World : Rethinking Curriculum and Pedagogy in the Age of Artificial Intelligence. Partners Universal Innovative Research Publication (PUIRP). *Partners Universal Innovative Research Publication (PUIRP)*, *1*(2), 112–136. https://doi.org/10.5281/zenodo.10245675

Grant, N. S., & Bolin, B. L. (2016). Digital storytelling: A method for engaging students and increasing cultural competency. *The Journal of Effective Teaching*, *16*(3), 44–61. https://files.eric.ed.gov/fulltext/EJ1125812.pdf

Huang, H. W. (2021). Effects of smartphone-based collaborative vlog projects on EFL learners' speaking performance and learning engagement. *Australasian Journal of Educational Technology*, *37*(6), 18–40. https://doi.org/10.14742/ajet.6623

Huang, L. (2023). Developing Intercultural Competence through a Cultural Metacognition-featured Instructional Design in English as a Foreign Language Classrooms. *Frontiers in Psychology*, *14*(February), 1–11. https://doi.org/10.3389/fpsyg.2023.1126141

Irie, K. (2021). Self-Efficacy. In *The Routledge Handbook of the Psychology of Language Learning and Teaching* (pp. 100–111). https://doi.org/10.1177/0032885512472964

Jin, S. H., Im, K., Yoo, M., Roll, I., & Seo, K. (2023). Supporting students' self-regulated learning in online learning using artificial intelligence applications. *International Journal of Educational Technology in Higher Education*, *20*(1), 1–21. https://doi.org/10.1186/s41239-023-00406-5

Kim, S. W. (2024). Development of a TPACK Educational Program to Enhance Pre-service Teachers' Teaching Expertise in Artificial Intelligence Convergence Education. *International Journal on Advanced Science, Engineering and Information Technology*, *14*(1), 1–9. https://doi.org/10.18517/ijaseit.14.1.19552

Kundu, A., & Bej, T. (2025). Transforming EFL Teaching with AI: A Systematic Review of Empirical Studies. In *International Journal of Artificial Intelligence in Education* (Issue 0123456789). https://doi.org/10.1007/s40593-025-00470-0

Lim, S. W., Jawaw, R., Jaidin, J. H., & Roslan, R. (2023). Learning history through project-based learning. *Journal of Education and Learning*, *17*(1), 67–75. https://doi.org/10.11591/edulearn.v17i1.20398

Lyublinskaya, I., & Kaplon-Schilis, A. (2022). Analysis of Differences in the Levels of TPACK: Unpacking Performance Indicators in the TPACK Levels Rubric. *Education Sciences*, *12*(2). https://doi.org/10.3390/educsci12020079

Meletiadou, E. (2022). Using Educational Digital Storytelling to Enhance Multilingual Students' Writing Skills in Higher Education. *IAFOR Journal of Education*, *10*(2), 111–130. https://doi.org/10.22492/ije.10.2.06

Miller, S. M. (2013). A research metasynthesis on digital video composing in classrooms: An evidence-based framework toward a pedagogy for embodied learning. *Journal of Literacy Research*, *45*(4), 386–430. https://doi.org/10.1177/1086296X13504867

Musliadi, M., Triyono, S., & Jamilah, J. (2024). Enhancing speaking agility: Unveiling Indonesian lecturers' hybrid teaching experiences in oral communication skills. *Language Learning in Higher Education*, *14*(2), 401–433. https://doi.org/10.1515/cercles-2024-0018

Nusrat, A., Khan, S., Kashif, F., & Fawad, R. (2022). Effect of teachers' asynchronous e-feedback and synchronous oral feedback on English language learners' writing accuracy. *Frontiers in Education*, *7*(July), 1–13. https://doi.org/10.3389/feduc.2022.783684

Owan, V. J., Abang, K. B., Idika, D. O., Etta, E. O., & Bassey, B. A. (2023). Exploring the potential of artificial intelligence tools in educational measurement and assessment. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(8), 1–15. https://doi.org/10.29333/ejmste/13428

Panigrahi, R., Srivastava, P. R., & Panigrahi, P. K. (2021). Effectiveness of e-learning: the mediating role of student engagement on perceived learning effectiveness. *Information Technology and People*, *34*(7), 1840–1862. https://doi.org/10.1108/ITP-07-2019-0380

Pratama, H., Putri, S. P., Bahri, S., Semarang, U. N., & Java, C. (2025). Potential Risks of ChatGpt-Assisted Essay Writing on Knowledge Retention Among EFLLearners In Indonesia. *Language and Education Journal, 10*(1), 148–168.

Qobilovna, A. M. (2023). Program for the Development of Primary School Teachers' Communicative Competence Factors. *International Journal of Pedagogics*, *03*(11), 131–137. https://doi.org/https://doi.org/10.37547/ijp/Volume03Issue12-31

Ruelens, E. (2019). Measuring language learner autonomy in higher education: The self-efficacy questionnaire of language learning strategies. *Language Learning in Higher Education*, *9*(2), 371–393. https://doi.org/10.1515/cercles-2019-0020

Said, Z., Mansour, N., & Abu-Tineh, A. (2023). Integrating technology pedagogy and content knowledge in Qatar's preparatory and secondary schools: The perceptions and practices of STEM teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(6). https://doi.org/10.29333/ejmste/13188

Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2018). The Importance of Attitudes toward Technology for Pre-Service Teachers' Technological, Pedagogical, and Content Knowledge: Comparing Structural Equation Modeling Approaches. *Computers in Human Behavior*, *80*, 67–80. https://doi.org/10.1016/j.chb.2017.11.003

Song, C., & Song, Y. (2023). Enhancing academic writing skills and motivation: assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students. *Frontiers in Psychology*, *14*(December), 1–14. https://doi.org/10.3389/fpsyg.2023.1260843

Southworth, J. (2022). Bridging Critical Thinking and Transformative Learning: The Role of Perspective-taking. *Theory and Research in Education*, *20*(1), 44–63. https://doi.org/10.1177/14778785221090853

Sutrisno, H. (2025). *Effectiveness of Project-Based Learning Model in Improving Critical Thinking Skills and Chemical Self-Efficacy*. *6*(1), 61–68. https://doi.org/10.46843/jiecr.v6i1.2041

Tantrarungroj, P., & Suwannatthachote, P. (2012). Enhancing Pre-service Teachers' Self-efficacy and Technological Pedagogical Content Knowledge in Designing Digital Media with Self-regulated Learning Instructional Support in Online Project-based Learning. *Creative Education*, *03*(08), 77–81. https://doi.org/10.4236/ce.2012.38b017

Tas, Y. (2016). The contribution of perceived classroom learning environment and motivation to student engagement in science. *European Journal of Psychology of Education*, *31*(4), 557–577. https://doi.org/10.1007/s10212-016-0303-z

Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J. M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, *11*(3). https://doi.org/10.3390/jintelligence11030054

Williams, R., Ali, S., Devasia, N., DiPaola, D., Hong, J., Kaputsos, S. P., Jordan, B., & Breazeal, C. (2023). AI + Ethics Curricula for Middle School Youth: Lessons Learned from Three Project-Based Curricula. In *International Journal of Artificial Intelligence in Education* (Vol. 33, Issue 2). Springer New York. https://doi.org/10.1007/s40593-022-00298-y

Zhang, Z. (2023). Collaborative Learning in Social Constructivism: Promoting English Learning in a Secondary Classroom in China. *Journal of Education and Educational Research*, *3*(3), 1–5. https://doi.org/10.54097/jeer.v3i3.9509

Zhussupova, R., & Shadiev, R. (2023). Digital storytelling to facilitate academic public speaking skills: a case study in a culturally diverse multilingual classroom. *Journal of Computers in Education*, *10*(3), 499–526. https://doi.org/10.1007/s40692-023-00259-x

Zimmerman, B. J. (2002). Becoming a Self-Regulated Learner: An Overview. *Theory into Practice*, *41*(2), 64–70. https://doi.org/https://doi.org/10.1207/s15430421tip4102_2