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The Effectiveness of Artificial Intelligence in Enhancing Critical and Creative Thinking within the Pancasila Student Profile Framework

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ABSTRACT

This study examined how Artificial Intelligence (AI) applications influence the development of critical thinking and creativity within the Pancasila Student Profile framework in Indonesia. Using a quasi-experimental pre-test/post-test control design, the research involved 64 eleventh-grade students in a six-week project-based learning unit on environmental issues. The experimental group employed various AI tools, while the control group relied on conventional approaches. Students' cognitive progress was assessed through validated essay tests and project rubrics. The results showed that AI integration led to substantially greater improvements in both critical thinking and creativity. Students in the AI-assisted group achieved significantly higher gains in critical thinking (5.63 vs. 2.18) and creativity (4.56 vs. 1.62), with large effect sizes indicating strong practical significance. These outcomes suggest that AI can function as a powerful cognitive amplifier, promoting deeper analytical thinking and more flexible idea generation. However, although AI enhanced cognitive aspects of the Pancasila Student Profile, it did not inherently support moral or social dimensions. Thus, future studies should investigate how AI can be combined with value-oriented and collaborative learning strategies to foster holistic development. Overall, the findings highlight the importance of adopting AI in balanced ways that advance higher-order thinking while upholding human-centered educational values.

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1. INTRODUCTION

In recent years, Artificial Intelligence (AI) has become one of the most important innovations in education around the world. Many countries now see AI as a powerful tool to support teaching and learning in schools and universities (Eager & Brunton, 2023). AI can provide personalized learning,

meaning that students can receive support that matches their own needs and abilities. It can also give instant feedback, correct mistakes in real time, and offer access to very large information sources within seconds (Dean, 2022). Because of these advantages, AI is often described as a "new paradigm" in education. It changes how teachers design lessons and how students learn. Global reports also show that AI is being used in language learning, science, mathematics, and even in skills training (Göktepe Yıldız & Göktepe Körpeoğlu, 2025). This shows that AI is not only a global trend but also a central part of the future of education.

In Indonesia, the influence of this global trend can also be clearly seen. Rahman (2024), Nurchurifiani (2025), and Azizah et al. (2025) found that teachers and students are beginning to use AI tools such as ChatGPT for brainstorming and idea generation, and Grammarly for language checking and writing improvement. These tools are now common in classrooms, especially in urban schools where internet access is more stable. Lalira, et al. (2024) and Rosdiana et al. (2024) discovered that teachers see AI as a way to make learning more effective and efficient. At the same time, the Indonesian education system is guided by a strong national vision, known as the Pancasila Student Profile (*Profil Pelajar Pancasila*). This profile is very important because it describes what kind of graduates Indonesia wants to produce. According to Irawati et al. (2022) and Utomo and Rilianti (2024), it does not only focus on intelligence but also on strong character, morality, respect for diversity, cooperation, critical thinking, creativity, and independence. This means that education in Indonesia must balance academic excellence with moral and social values.

Here, a key problem appears. While AI can improve some cognitive skills such as information processing, logical reasoning, and writing, there are concerns that it may not automatically help students to build social, moral, and emotional skills (Lin & Van Brummelen, 2021). In fact, there are fears that over-reliance on AI could make students dependent on machines, reduce their ability to think deeply, and even weaken their originality. For example, when students receive ready-made answers from AI without reflection, they may lose the chance to develop independent thinking. This is a serious issue in Indonesia, because the Pancasila Student Profile requires balance: students must be both smart and good in character. According to Celik et al. (2022) and Sasirekha (2024), if AI is not used carefully, it may create an imbalance by developing only part of the profile (critical thinking and creativity) while ignoring others (morality, cooperation, and global citizenship).

Several previous studies in Indonesia and beyond have examined the impact of Artificial Intelligence (AI) on students' cognitive and creative skills. For instance, Yuliani et al. (2024) and Brazão and Tinoca (2025) reported that AI use can enhance students' critical thinking and creativity, particularly in higher education contexts. Similarly, Azamatova et al. (2023) and Wei (2023) found that AI-assisted project-based learning significantly improved students' collaboration and motivation in foreign language classes. However, many of these studies relied primarily on self-report surveys or interviews, which tend to capture perceptions rather than measurable learning outcomes. Self-reports can introduce bias because students may respond based on attitudes or expectations rather than actual performance.

Other researchers have highlighted potential risks of AI integration. Syarifah and Fakhruddin (2024) and Georgiou (2025) observed that students using AI for writing assistance often exhibit "cognitive shallowness," relying on generated answers without deep understanding or originality. Zhai et al. (2024), in a systematic review, also cautioned that excessive dependence on AI tools can reduce students' self-regulation, recommending teacher guidance to ensure reflective learning. Elbadiansyah et al. (2024) and Deckker and Sumanasekara (2025) further demonstrated that while AI can improve motivation and cognitive engagement, its influence on emotional and moral dimensions remains limited. Faisal (2024) and Yavich (2025) similarly found that students' critical reasoning improved through AI use but warned that overreliance could diminish independent thinking.

These studies collectively indicate that although AI shows strong potential for enhancing higher-order thinking, important research gaps remain. First, few controlled experimental studies in Indonesia have measured the direct effects of AI on actual student performance rather than perceptions. Second,

limited evidence exists on how AI influences measurable competencies within the framework of the *Pancasila Student Profile*. Third, previous research seldom identifies which components of critical thinking (e.g., analysis, evaluation, or self-regulation) or creativity (e.g., fluency, flexibility, originality, or elaboration) benefit most from AI integration. Addressing these gaps is essential for designing pedagogical strategies that balance AI's cognitive benefits with moral and social values.

To address these gaps, this study focuses on two main skills that are central to both global education and the Pancasila Student Profile: critical thinking and creativity. These two skills are essential for students in the 21st century because they help them solve complex problems, adapt to new challenges, and create innovative solutions. This study does not only rely on perceptions but uses a quasi-experimental design with pre-tests and post-tests, and performance-based instruments to measure students' real progress. By doing so, the study provides stronger evidence on how AI affects learning. The specific research question is: *Does the structured use of AI tools in a project-based learning environment significantly improve students' critical thinking and creativity compared to conventional methods?*

By focusing on this question, the study contributes both to theory and practice. For theory, it adds empirical evidence about the cognitive benefits of AI in education, especially in the Indonesian context where the Pancasila Student Profile is the guiding framework. For practice, it provides teachers and policymakers with concrete information about how AI can be used to strengthen critical and creative skills without losing sight of moral and social goals. In this way, the study hopes to support balanced and meaningful AI integration in Indonesian schools.

2. METHODS

This study utilized a quasi-experimental design with a non-equivalent control group and pre-test/post-test measures. This design was selected because fully random assignment of individual students was not practical within the existing school class structure. Instead, intact classes were assigned to either the experimental or control condition. The design involved administering a pre-test (O1) to both groups, followed by the implementation of the treatment (X), which was the integration of AI tools into a project-based learning unit, for the experimental group only. The control group participated in the same project-based learning unit but without AI integration. Finally, a post-test (O2) was administered to both groups to measure the difference in outcomes.

The research was conducted at one public high school (Sekolah Menengah Atas Negeri) in Surabaya, Indonesia. Selecting a single-school setting was a deliberate choice to control for extraneous variables such as differences in school culture, socio-economic background of the student body, and institutional technology support. Participants were 11th-grade students. Two classes with similar average academic performance, as determined by school records, were selected using a purposive sampling technique. One class was randomly assigned as the experimental group (n=32), and the other served as the control group (n=32), resulting in a total of 64 participants aged 16-17 years. Informed consent was obtained from the school principal, parents, and all student participants before the commencement of the study.

Two main instruments were used to collect data, both focusing on direct performance-based assessment rather than self-report questionnaires. The first was a Critical Thinking Skills Test, developed as an essay test based on a framework adapted from Facione (1990). It measured five indicators: identification, analysis, evaluation, inference, and self-regulation. Students responded to a case study about a local socio-scientific dilemma. A detailed scoring rubric with a scale of 0-4 for each indicator was used, yielding a total maximum score of 20. The instrument's content validity was established through review by two experts in educational assessment and critical thinking. Inter-rater reliability, calculated using the Intraclass Correlation Coefficient (ICC) on a sample of essays scored by two independent raters, was excellent (ICC = 0.87).

The second instrument was a Creativity Assessment Rubric, adapted from the Torrance Tests of Creative Thinking (TTCT). It was used to assess the final project output (written report and presentation) across four dimensions: fluency, flexibility, originality, and elaboration. Each dimension

was scored on a 0-5 scale, resulting in a total maximum score of 20. The rubric included specific descriptors for each score level. Similar to the first instrument, content validity was verified by experts, and inter-rater reliability was high (ICC = 0.84).

The intervention spanned six weeks and was structured around a project-based learning (PBL) unit titled "Innovative Solutions for Local Environmental Issues." During the first week, both groups completed the pre-test (O1) and received an orientation to the PBL project. The core intervention occurred from weeks two to five. The experimental group integrated AI tools—specifically ChatGPT and Grammarly—into their workflow. In week two, they used ChatGPT for brainstorming and idea generation. In week three, the tool was used for initial research and gathering diverse perspectives, with guidance on critical source evaluation. During week four, students drafted their reports using Grammarly for grammatical refinement and ChatGPT for suggestions on improving argument structure. Week five focused on synthesis and finalization, culminating in a reflective discussion on their use of AI. Conversely, the control group completed the identical PBL project using conventional, non-AI methods, such as library research, textbooks, and peer/teacher feedback. In the sixth and final week, both groups completed the post-test (O2).

The six-week duration was justified as it aligns with the typical timeframe for implementing a complete PBL cycle, as supported by similar studies (e.g., Mursid, Saragih, & Hartono, 2021; Bytyqi, 2022). This period was deemed sufficient for the potential effects of the AI tools on cognitive and creative processes to become observable, while remaining practical within the constraints of the academic calendar.

Data analysis was performed using SPSS version 25. Descriptive statistics, including means and standard deviations, were calculated for the pre-test and post-test scores of both groups. The primary analysis involved comparing the gain scores (calculated as post-test score minus pre-test score) for critical thinking and creativity between the experimental and control groups. After confirming the normality of the gain score distributions using the Shapiro-Wilk test, independent samples t-tests were conducted to determine if there were statistically significant differences between the groups. A significance level of $p < 0.05$ was used for all inferential tests.

3. FINDINGS AND DISCUSSION

This section presents the empirical results of the study, focusing on descriptive statistics, inferential tests, effect sizes, and subcomponent analyses for both critical thinking and creativity.

Descriptive Statistics

Table 1 shows the descriptive data for pre-test, post-test, and gain scores for both groups.

Table 1. Descriptive Statistics for Pre-test, Post-test, and Gain Scores

Group	Measure	Pre-test Mean (SD)	Post-test Mean (SD)	Gain Score Mean (SD)
Experimental (n=32)	Critical Thinking	10.25 (2.31)	15.88 (2.67)	5.63 (1.42)
	Creativity	9.47 (1.89)	14.03 (2.15)	4.56 (1.37)
Control (n=32)	Critical Thinking	10.41 (2.18)	12.59 (2.34)	2.18 (1.28)
	Creativity	9.63 (1.95)	11.25 (2.07)	1.62 (1.15)

Both groups started with comparable pre-test scores, indicating equivalent initial abilities. However, post-test means show substantially higher improvements for the experimental group in both critical thinking and creativity.

Inferential Statistics: t-test Results and Effect Sizes

To determine whether these differences were statistically significant, independent samples t-tests were conducted on gain scores.

Table 2. Independent Samples t-test Results for Gain Scores

Variable	Group	Mean Gain	SD	t-value	df	p-value	Cohen's d
Critical Thinking	Experimental	5.63	1.42	10.45	62	< 0.001	1.65
	Control	2.18	1.28				
Creativity	Experimental	4.56	1.37	9.21	62	< 0.001	1.46
	Control	1.62	1.15				

The results show significant differences between the experimental and control groups for both variables. Improvements in critical thinking were highly significant ($p < 0.001$; $d = 1.65$), while creativity also increased markedly ($p < 0.001$; $d = 1.46$). The large effect sizes indicate substantial practical importance, demonstrating that the AI-based intervention produced meaningful cognitive gains.

Subcomponent Analysis

A deeper analysis of the subcomponents of both critical thinking and creativity (Table 3) provides a more comprehensive picture of how AI integration influenced students' cognitive development. The data reveal that, within critical thinking, the largest gains in the experimental group occurred in analysis and evaluation, suggesting that AI tools effectively supported students in examining arguments and assessing evidence critically. Self-regulation, while showing improvement, increased more modestly, indicating the need for continued teacher guidance in reflective thinking. In terms of creativity, notable gains were observed in fluency and flexibility, reflecting students' enhanced ability to generate diverse ideas and consider multiple perspectives when solving problems. Meanwhile, originality and elaboration also improved but remained more dependent on students' independent exploration and teacher feedback. Collectively, these findings highlight that AI-assisted learning promotes analytical depth and idea diversity, yet still requires human facilitation to strengthen reflective and original thought processes.

Table 3. Detailed Analysis of Critical Thinking and Creativity Components

Component Type	Subcomponent	Experimental Group Gain Mean	Control Group Gain Mean	Description
Critical Thinking	Identification	1.25	0.53	Ability to recognize key issues and relevant information in a problem context.
	Analysis	1.41	0.47	Skill in breaking information into parts and examining logical relationships.
	Evaluation	1.12	0.41	Competence in assessing credibility, validity, and argument strength.
	Inference	1.05	0.38	Ability to draw logical conclusions based on given evidence.
	Self-regulation	0.80	0.39	Capacity to monitor, reflect, and adjust one's reasoning process.
Creativity	Fluency	1.28	0.45	Number of ideas or solutions generated within a given time or task.
	Flexibility	1.17	0.43	Ability to shift perspectives and explore diverse categories of ideas.
	Originality	0.92	0.40	Uniqueness and novelty of ideas beyond conventional thinking.
	Elaboration	0.84	0.37	Depth and detail in developing and refining ideas into complete products.

Table 3 illustrates that AI-integrated learning produced higher gains across all components of both critical thinking and creativity. In critical thinking, analysis and evaluation showed the largest improvements, indicating that AI tools helped students in examining and assessing arguments critically. Meanwhile, in creativity, fluency and flexibility recorded the highest mean gains, reflecting how AI tools such as ChatGPT encouraged students to generate multiple ideas and explore varied perspectives. Originality and elaboration also improved but remained more dependent on students' independent reflection and teacher scaffolding.

Visual Summary

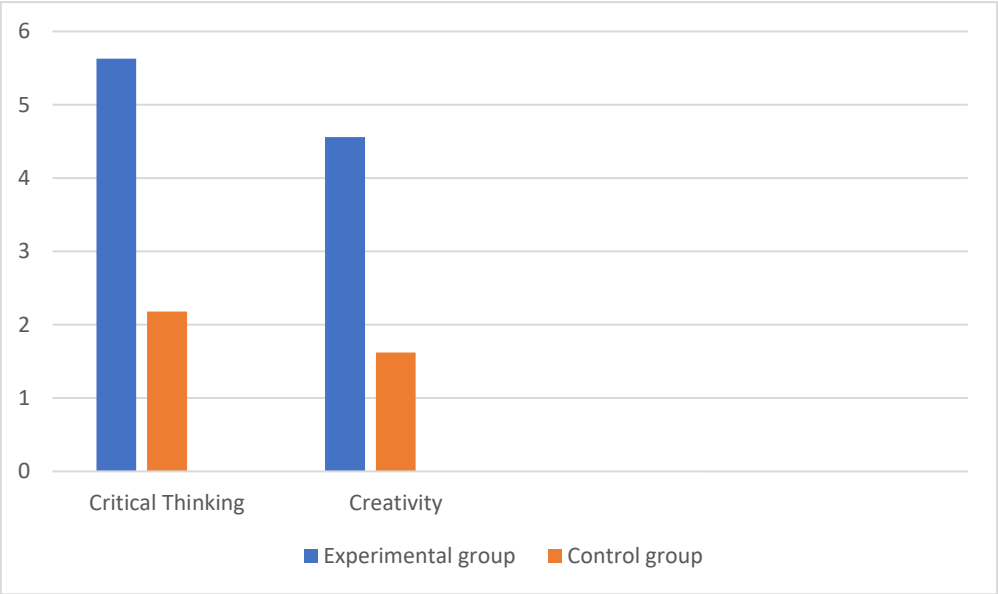

Figure 1. visual comparison of mean gain scores for critical thinking and creativity.

Figure 1 presents a clear visual comparison of the mean gain scores between the experimental and control groups for both critical thinking and creativity. The differences are substantial and statistically significant.

For critical thinking, students in the experimental group achieved a mean gain score of 5.63, which is more than two and a half times higher than the control group's 2.18. This indicates that the use of AI tools—ChatGPT and Grammarly—helped students improve their analytical reasoning, evaluation, and inference abilities far beyond those of students who relied solely on conventional methods.

Similarly, for creativity, the experimental group's mean gain was 4.56, compared to only 1.62 in the control group, representing an improvement ratio of nearly three to one. This demonstrates that AI-supported project-based learning encouraged students to produce a greater variety of ideas (fluency) and to approach problems from multiple perspectives (flexibility).

Overall, the bar graph visually reinforces the statistical findings presented in Table 2, highlighting the strong cognitive impact of AI-integrated learning. The experimental group's gains are consistently higher across both domains, confirming that structured AI use can substantially enhance critical and creative thinking in educational settings.

Observation

Classroom observations during the intervention revealed a noticeable transformation in the way students interacted with learning materials and peers when using AI tools. Students in the experimental group demonstrated greater enthusiasm and participation during group discussions, especially when brainstorming ideas for their project-based assignments. The use of ChatGPT encouraged them to explore a wider range of perspectives and examples, which in turn stimulated curiosity and critical questioning. They were often seen comparing AI-generated responses, debating which ideas were more relevant or original, and collaboratively refining their project concepts. This active engagement stood in contrast to the control group, where students tended to depend more on textbooks and teacher explanations, resulting in fewer spontaneous exchanges of ideas.

From the teachers' perspective, students using AI displayed increased confidence in articulating their arguments and presenting their project drafts. Grammarly, in particular, provided immediate linguistic feedback that helped students express their thoughts more clearly and with better structure. Teachers noted that students became more self-assured in explaining their reasoning and defending

their conclusions during class presentations. However, several teachers also observed a growing tendency among some students to accept AI-generated suggestions without sufficient critical reflection. For example, a few learners copied text from ChatGPT outputs without questioning its accuracy or contextual relevance. This pattern highlighted that while AI can boost productivity and surface-level confidence, it does not automatically nurture the deeper reflective habits essential for independent learning.

These qualitative insights closely align with the quantitative findings that showed the lowest improvement in the self-regulation component compared to analysis and evaluation. Students demonstrated notable progress in analytical reasoning and idea generation—evident in their ability to organize information and produce multiple creative solutions—but they were less consistent in monitoring and evaluating their own thought processes. This indicates that while AI tools effectively scaffold cognitive skills such as analysis, fluency, and flexibility, they offer limited support in fostering metacognitive awareness. Therefore, future implementations of AI-assisted learning should include structured reflection sessions, teacher-led debriefings, and peer review activities to encourage students to critically assess their use of AI and internalize the reasoning process behind their outputs. Such practices will ensure that AI serves not only as a source of knowledge but also as a catalyst for self-directed and value-based learning in line with the *Pancasila Student Profile*.

Discussion

The findings of this study provide a clear and affirmative answer to the research question: integrating Artificial Intelligence (AI) tools within a structured project-based learning (PBL) framework significantly enhances students' critical thinking and creativity compared with conventional instruction. Quantitatively, the large effect sizes (Cohen's d = 1.65 for critical thinking and d = 1.46 for creativity) demonstrate that AI integration produces not only statistically significant but also practically meaningful learning gains. These results substantiate the claim that AI, when appropriately mediated by pedagogy, can act as a transformative learning scaffold rather than a mere digital aid.

From a theoretical standpoint, these outcomes align with Lin and Van Brummelen (2021) and Sætra (2022), who conceptualize AI as a "cognitive amplifier" that enhances human reasoning by providing real-time scaffolding within the learner's zone of proximal development. In this study, AI tools functioned as dynamic mediators that offered contextual feedback, alternative viewpoints, and linguistic support—thereby expanding students' capacity for analysis and evaluation. This mechanism corresponds closely with Vygotskian constructivism, wherein external supports, such as technology or expert guidance, enable learners to perform beyond their independent capability. The observed improvements in the analysis and evaluation components of critical thinking confirm earlier findings by Yuliani et al. (2024), Sako (2024), and Azamatova et al. (2023) who reported that AI-facilitated learning fosters higher-order reasoning, deeper engagement, and sustained motivation, particularly when embedded within collaborative tasks.

Furthermore, the study's findings reinforce the argument of Indrašienė et al. (2023) and Campo et al. (2023), who emphasize the role of critical reflection in developing students' thinking skills. The structured use of AI within project-based learning enabled learners to repeatedly analyze, critique, and refine ideas based on automated feedback and peer discussions (Kong, Cheung, & Tsang, 2024). This iterative learning process likely contributed to the significant gains in analytical reasoning observed in the experimental group. In essence, AI tools provided immediate cognitive scaffolds, while teacher-facilitated discussions transformed those interactions into opportunities for reflection and metacognitive awareness—a combination that proved particularly effective for higher-order thinking development (Lee, 2023).

In terms of creativity, the findings reveal pronounced improvements in fluency and flexibility, supporting Adiyono et al. (2025) and Garbuio & Lin (2021), who describe AI as an efficient idea generator that enhances learners' ability to explore multiple pathways for problem-solving. ChatGPT's role as a brainstorming assistant allowed students to transcend habitual thought patterns and engage

in more divergent thinking. This aligns with the Torrance framework, which associates creativity not only with originality but also with the capacity to produce varied and contextually appropriate ideas. Nonetheless, the relatively smaller gains in originality and elaboration corroborate the caution expressed by Faisal (2024) and Zhai et al. (2024) that uncritical dependence on AI-generated outputs can lead to "cognitive shallowness" or reduced self-driven innovation. These results underscore the need for deliberate teacher intervention to ensure that AI functions as a catalyst for creativity rather than a substitute for it.

Comparatively, the current findings extend the insights of Elbadiansyah et al. (2024) and Zhou and Hou (2024), who found that while AI enhances students' motivation and cognitive engagement, it has limited impact on emotional and moral development. In the present study, the absence of explicit measures for moral and social competencies aligns with this limitation. Irawati et al. (2022) and Asri et al. (2025) explains that although AI-assisted learning effectively strengthened the cognitive dimensions of the *Pancasila Student Profile*—particularly critical reasoning and creativity—it did not address the equally vital domains of faith, ethics, and collaboration, which are central to holistic education in Indonesia. This underscores the importance of integrating AI tools within value-based pedagogical designs that explicitly nurture empathy, cooperation, and integrity—values that are foundational to the *Pancasila* philosophy.

From a methodological perspective, this study contributes to bridging a persistent gap in Indonesian AI-in-education research. As noted in the literature, most prior studies such as Yuliani et al. (2024) and Syarifah and Fakhruddin (2024), relied on self-reported data or qualitative perceptions, rather than controlled experimental designs using performance-based instruments. By employing a quasi-experimental design with validated tests and rubrics, this research provides robust empirical evidence of AI's measurable effects on cognitive performance. Such evidence strengthens the argument advanced by Zhai et al. (2024) and Lee and Li (2024) that teacher-guided AI use can yield deep learning outcomes—provided that reflection, self-regulation, and ethical reasoning remain integral to the instructional design.

Despite its strong results, the study acknowledges several limitations. The intervention's six-week duration limited the assessment of long-term skill retention. Additionally, the sample was drawn from a single urban public school, which constrains generalizability across diverse educational contexts, particularly rural or resource-limited settings where access to AI tools remains uneven. Moreover, the study did not measure affective or moral outcomes, which are essential aspects of the *Pancasila Student Profile*. Future research should therefore adopt mixed-method or longitudinal designs to examine how AI influences the sustained development of character, collaboration, and socio-emotional intelligence over time.

Theoretically, this research enriches the body of knowledge on AI-assisted constructivist learning, confirming that AI can foster meaningful engagement and reflective cognition when paired with sound pedagogy. Practically, it offers educators a concrete model for embedding AI tools within project-based and reflective learning frameworks, aligning with recommendations by Bytyqi (2021) and Mursid et al. (2021) that project-based learning can make technology integration both authentic and contextually relevant. Pedagogical strategies that balance AI-driven cognitive support with teacher-guided reflection and ethical discourse could help Indonesian schools operationalize the *Pancasila Student Profile* more holistically.

From a philosophical and educational standpoint, this study reiterates that AI should serve—not supplant—human reasoning and ethical judgment. As van de Poel (2020) and Renz & Vladova (2021) remind, embedding human values into AI systems is crucial to prevent dehumanization in education. In the context of *Pancasila*-oriented learning, technology must remain subordinate to humanistic principles that prioritize moral character, empathy, and social responsibility. Critical and creative thinking, therefore, should not exist in isolation but in harmony with the ethical and spiritual dimensions of learning. A balanced pedagogical paradigm, where AI amplifies cognition while

educators cultivate humanity, reflects the true essence of Pancasila-inspired digital education—one that embraces innovation without losing its moral compass.

4. CONCLUSION

This study demonstrates that integrating Artificial Intelligence (AI) tools into project-based learning significantly enhances students' critical thinking and creativity skills. The quasi-experimental design involving 11th-grade students in Surabaya showed that the AI-assisted group achieved considerably higher gains than those taught through conventional methods. These findings confirm AI's strong potential to support the cognitive dimensions of the *Pancasila Student Profile*, especially in developing analytical reasoning, evaluative judgment, and creative problem-solving. However, the study also reveals that AI integration alone cannot foster the profile's broader aspects—such as moral character, empathy, and collaboration—which require complementary pedagogical strategies rooted in values and social interaction.

Practically, this study recommends that educators embed AI tools within structured and reflective learning frameworks, ensuring that technology use remains balanced with character education. Teachers should guide students to critically evaluate AI outputs and use them as catalysts for inquiry, not substitutes for thinking. For future research, longitudinal and mixed-method studies are needed to explore the sustainability of AI-driven cognitive gains and its potential to nurture other aspects of the *Pancasila Student Profile*. Broader investigations across diverse educational contexts, including rural schools and *pesantren*, would also help ensure that AI integration in Indonesian classrooms advances both intellectual growth and moral integrity, reflecting the humanistic ideals of *Pancasila*-based digital education.

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