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DEVELOPMENT OF A PROJECT-BASED LEARNING MODEL ASSISTED BY DEEPAI TO IMPROVE LEARNERS' CREATIVITY AND DIGITAL LITERACY

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Abstrak
Penelitian ini bertujuan untuk mengembangkan dan menguji model Project-Based Learning digital yang terintegrasi dengan teknologi DeepAI dalam konteks pembelajaran Prakarya di jenjang sekolah menengah pertama. Model yang dikembangkan dirancang untuk menstimulasi kreativitas dan literasi digital pebelajar melalui penerapan kecerdasan buatan berbasis Deep Learning pada setiap tahapan proyek. Pendekatan penelitian ini menggunakan metode pengembangan dengan acuan model Dick, Carey & Carey, yang diadaptasi ke dalam tujuh tahap utama PjBL sebagaimana dikemukakan oleh Larmer dan Boss. Proses implementasi dilakukan bersama guru dan pebelajar dalam kegiatan pembelajaran yang menekankan kolaborasi, eksplorasi ide, serta penerapan teknologi digital secara reflektif. Data penelitian dikumpulkan melalui kombinasi metode kuantitatif dan kualitatif, mencakup observasi, wawancara, serta penilaian terhadap karya dan aktivitas pebelajar. Hasil penelitian menunjukkan adanya peningkatan kemampuan berpikir kreatif dan literasi digital yang nyata setelah penerapan model ini. Pebelajar menjadi lebih aktif dalam mengembangkan ide orisinal, mengintegrasikan hasil rancangan AI dengan gagasan pribadi, serta menampilkan hasil proyek dalam format digital secara mandiri dan kolaboratif. Temuan kualitatif juga memperlihatkan bahwa penggunaan DeepAI mampu memperkaya pengalaman belajar dengan mendorong eksplorasi ide, refleksi diri, dan kerja sama dalam tim. Secara keseluruhan, integrasi DeepAI dalam PjBL terbukti mendukung pembelajaran Prakarya yang inovatif, kolaboratif, dan bermakna, sejalan dengan prinsip pembelajaran mendalam yang menjadi orientasi Kurikulum Nasional.

Kata Kunci: DeepAI; Pembelajaran Berbasis Proyek; kreativitas; Literasi Digital; Prakarya

Abstract
This study aims to develop and evaluate a digital Project-Based Learning model integrated with DeepAI technology in Craft Education at the junior high school level. The model is designed to stimulate students' creativity and digital literacy through the application of Deep Learning-based artificial intelligence across each stage of project implementation. The research employed a Research and Development approach adapted from the Dick, Carey and Carey model, implemented through the seven essential phases of PjBL as outlined by Larmer and Boss. The model was applied collaboratively with teachers and students, emphasizing digital exploration, reflective learning, and collaborative project creation. Data were collected using a mixed-method approach, including observation, interviews, and performance assessments of student projects and activities. The findings indicate a substantial improvement in students' creative thinking and digital literacy after the implementation of the proposed model. Learners became more capable of generating original ideas, integrating AI-generated outputs with their own concepts, and presenting digital projects in collaborative and independent ways. Qualitative results also reveal that the use of DeepAI enriched the learning experience by fostering idea exploration, self-reflection, and teamwork. Overall, integrating DeepAI into PjBL effectively promotes innovative, collaborative, and meaningful learning in Craft Education, aligning with the principles of Deep Learning pedagogy embedded in the current National Curriculum.

Keywords*: DeepAI; Project-Based Learning; Creativity; Digital Literacy; Craft Education*

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INTRODUCTION

The Industrial Revolution 4.0 and the transformation towards Education 5.0 have fundamentally changed the learning paradigm in secondary schools, including in the Craft subject, which demands a synergy between creativity, collaboration, and digital literacy. According to Ratniyom et al. (2025), the Deep Learning era in education emphasizes the importance of the teacher's role as an activator of learning, facilitating deep student engagement through meaningful projects and exploration. In this context, technology, including Artificial Intelligence (AI), is not intended to replace teachers, but rather to expand creative, reflective, and learner-centered learning spaces, as per the principles of constructivist learning (S. K. Kim et al., 2025). A recent study by Yang et al. (2025) confirmed that a Creative Project-Based Learning approach that adaptively integrates AI agents can foster creativity and collaboration from early secondary school, making technology a thinking partner, not just a tool.

21st-century learning demands competencies that are not only cognitive but also encompass creative and critical thinking skills and project-based problem-solving (Eliza et al., 2025). Within this framework, AI integration has become a strategic direction for innovation in Educational Technology due to its ability to enrich the learning experience and support adaptive learning (Bahroun et al., 2023; Kong et al., 2024). One of the most relevant approaches is Deep Learning, a machine learning model that uses multi-layered neural networks to recognize complex patterns and build hierarchical knowledge representations (LeCun et al., 2015). A study by Zha et al. (2025) in Education and Information Technologies confirmed that the application of AI-supported creative learning in a STEAM context has been shown to enhance innovation, problem-solving, and design thinking skills in secondary school students.

In the educational context, the concept of Deep Learning has two complementary dimensions. Technologically, Deep Learning refers to AI systems capable of learning from data and generating adaptive solutions (LeCun et al., 2015; Naseer et al., 2024). However, in a pedagogical context, particularly in the Indonesian National Curriculum, the term deep learning emphasizes a meaningful, reflective, and enjoyable learning process, with an integration of thought, heart, feeling, and exercise to form a complete conceptual and contextual understanding (Kemendikdasmen, 2025). The integration of these two meanings has become the focus of recent research in AI Literacy Frameworks that combine Project-Based Learning (PjBL) and AI-driven reflection (Kong et al., 2024; C. Liu et al., 2024). This approach has proven effective in increasing ethical awareness, reflective thinking skills, and data-driven problem-solving in learners.

This research seeks to bridge these two meanings by developing a digital PjBL model integrated with DeepAI technology, a generative artificial intelligence platform based on deep learning. This model is applied in Craft learning in junior high schools to enrich idea exploration, design creativity, and digital collaboration. According to Larmer et al., (2015), PjBL emphasizes seven main steps: inquiry, planning, developing, creating, reflecting, presenting, and evaluating, which have been proven effective in enhancing learner creativity and collaboration (Mergendoller & Thomas, 2018). A study by Chen et al., (2023) showed that the integration of generative AI in PjBL expands the interaction between human and machine ideas, resulting in creative synergy that deepens learners' thinking processes. However, initial observations at Tahta Syajar Junior High School indicate that Craft learning remains conventional, dominated by lectures and written assignments, with low active learner involvement and limited use of digital technology (Aprianto et al., 2023; Putra et al., 2022). This situation indicates an instructional gap between the potential of AI for creative learning and actual classroom practice.

This gap provides an important basis for integrating DeepAI technology into the PjBL model. Through the use of DeepAI, learners can generate visual inspiration, design concepts, and alternative creative solutions supported by digital data. Teachers can use AI as a tool to provide project guidance, automated feedback, and portfolio-based assessment (Chen et al., 2023). Similar findings were presented by Kinder et al. (2025), who confirmed that adaptive AI feedback systems in creative projects help learners develop higher-order thinking skills through contextual, reflective feedback. This integration does not replace the role of the teacher, but rather expands the facilitator's function in constructivist learning contexts (Piaget, 1969; S. K. Kim et al., 2025). Furthermore, a study by Fütterer et al. (2025) reinforces the role of teacher orchestration in managing interactions between learners and AI systems to ensure that learning remains human-centered.

Besides fostering creativity, another key dimension of digital learning is digital literacy. Redecker & Punie (2017) explain that digital literacy encompasses the ability to use technology critically and ethically to produce, evaluate, and communicate information. In the context of digital PjBL, digital literacy enables learners to collaborate, communicate, and innovate using technology with social responsibility. A study (Ma et al., 2025) emphasized that ethical AI literacy needs to be taught from elementary and secondary education to ensure learners are able to recognize algorithm bias and manage data responsibly. Research (Khuluq et al., 2023) also shows that digital PjBL improves learners' critical thinking and collaborative skills. However, the application of generative AI, such as DeepAI, in the context of craft projects is still very limited and rarely studied empirically in Indonesia.

Thus, this study positions DeepAI as a supporting technology that can strengthen two key competencies in Craft learning: creativity and digital literacy. This integration is expected to not only improve the quality of students' project outcomes but also foster reflective, adaptive, and responsible thinking skills in response to technological advancements. In line with the findings of Fu & Weng (2024), AI-based project learning has been shown to significantly improve learning outcomes and student engagement through context-based digital experiences. Therefore, this study aims to develop and test a digital PjBL model integrated with DeepAI in Craft learning at Tahta Syajar Middle School. It also analyzes the improvement in students' creativity and digital literacy after implementing the model. It also describes teacher and student perceptions of the effectiveness of AI-assisted PjBL.

The theoretical foundation of PjBL is rooted in constructivism theory, which positions students as active agents in constructing knowledge through authentic and contextual project activities (Wang et al., 2024). Larmer et al. (2015) explain that the Gold Standard for PjBL encompasses seven key design elements: Challenging Problem or Question, Sustained Inquiry, Authenticity, Student Voice and Choice, Reflection, Critique and Revision, and Public Product. These elements encourage learners to connect academic concepts to real-life situations, making the learning process meaningful. Eliza et al. (2025) add that digital PjBL expands opportunities for exploration and collaboration across resources, including artificial intelligence technology. Research by Aprianto et al. (2023) demonstrates that digital-based PjBL increases learners' motivation and originality of ideas, while Khuluq et al. (2023) confirms an increase in reflective thinking skills at the junior high school level. Furthermore, Shen et al. (2025) highlight that AI-human co-creativity frameworks in education can strengthen the relationship between idea exploration and learners' personal expression in technology-based projects.

The concept of Deep Learning as a technology and learning approach can be integrated in the context of Educational Technology. Technologically, Deep Learning underpins systems such as

DeepAI, ChatGPT, and adaptive recommendation systems (Naseer et al., 2024). Pedagogically, deep and meaningful learning requires conceptual understanding, reflection, and knowledge transfer (X. Tan et al., 2025). By utilizing DeepAI as a representation of AI-based Deep Learning, learners can deepen their thinking processes through visual exploration, reflection on ideas, and generative production, enriching the learning experience (Bahroun et al., 2023). This approach aligns with the spirit of the Indonesian National Curriculum, which emphasizes reflective, collaborative, and project-based learning (Kemendikdasmen, 2025).

Creativity in Crafts is defined as the ability to generate new and useful ideas and products (Runco & Jaeger, 2012). This creative process focuses not only on the final result but also on the exploration of ideas, reflection, and innovation (Torrance, 1974). DeepAI technology expands this exploration space by providing visual inspiration and design alternatives that enrich learners' creative thinking processes (Bahroun et al., 2023). The collaboration between human creativity and AI is complementary, with AI accelerating the exploration of ideas, while learners determine their aesthetic value and functionality. The integration of DeepAI–PjBL not only enriches the learning experience but also represents a new form of pedagogical innovation relevant to the digital transformation of education in Indonesia. In line with the findings of Ratniyom et al., (2025), learning that combines technology, collaboration, and reflection has the potential to create deep learning that is not only outcome-oriented but also transforms learners' thinking.

METHOD

This research uses a Research and Development approach combined with empirical field research as the primary design. The development model refers to the Instructional Design Model by Dick, Carey & Carey, which consists of ten systematic steps, from identifying learning objectives to summative evaluation. This approach was chosen because it ensures comprehensive integration between needs analysis, design, implementation, and evaluation of learning. This R&D model is also recommended in the context of AI-supported pedagogy because it ensures continuity between technology design and pedagogical practice (Kong et al., 2024; Yang et al., 2025).

This research focuses on the development and effectiveness testing of a digital PjBL model integrated with DeepAI technology in Craft learning. This model combines the principles of the constructivist learning environment of S. K. Kim et al. (2025) with the potential for AI-driven creativity enhancement (Bahroun et al., 2023). The research design consists of two main stages: the model development stage, which includes needs analysis, design, expert validation, and design revision; and the model development stage, which includes needs analysis, design, expert validation, and design revision. and an empirical trial phase involving the application of the model to Craft learning in eighth-grade students at Tahta Syajar Middle School and an analysis of its effectiveness using quantitative and qualitative approaches.

The research activities were conducted during the even semester of the 2024/2025 academic year. The research subjects consisted of 43 eighth-grade students and two Craft teachers who played an active role in the project development and implementation process. The location and subjects were selected using a purposive sampling technique, taking into account the school's readiness for digital media use and the teachers' willingness to collaborate. The school already has a Google Classroom-based and a computer laboratory that allows for the integration of DeepAI as a medium for exploring ideas and project designs. These facilities are also essential prerequisites for the successful implementation of AI-supported PjBL, as emphasized by Tan et al. (2025) and Ingason et al. (2025), who found that digital infrastructure readiness significantly determines the effectiveness of artificial intelligence-based learning in schools.

The research procedure adapted the stages of the Dick, Carey & Carey model with the Gold Standard PjBL framework from Larmer et al., 2015. This adaptation resulted in seven main steps in model development: identifying learning objectives through observations and interviews with Craft teachers to identify gaps between ideal and actual conditions; analyzing learning by mapping core competencies and sub-competencies in the topic of inorganic waste processing; analyzing learner characteristics, including initial abilities, learning styles, and digital readiness; formulating performance objectives and success indicators; developing DeepAI-based learning strategies and media, such as using the DeepAI Image Generator to explore visual project ideas; expert validation by two Educational Technology experts and one Craft expert; and implementing and formative evaluation through one-on-one, small group, and field testing. This seven-step approach aligns with the recommendations of Kong et al. (2024) and Lee & Wu (2025), who emphasize the importance of reflection, collaboration, and intelligent feedback in AI-based project design.

This research employed a mixed methods approach. Quantitative data were collected through a creativity test using a rubric based on the Torrance Test of Creative Thinking (TTCT) (Torrance, 1974), which assesses four key indicators: fluency, flexibility, originality, and elaboration. In addition, a digital literacy questionnaire was developed based on the European Digital Competence Framework (DigComp) indicators (Redecker & Punie, 2017) with 25 items on a 1–5 Likert scale. A mixed methods approach was chosen to gain a comprehensive understanding of the learning process and outcomes, as recommended by Shen et al. (2025), who emphasized the need for triangulation of quantitative and qualitative data in research on AI-assisted learning environments.

Qualitative data were obtained through participant observation during the project process, semi-structured interviews with teachers and learners regarding their perceptions of the use of DeepAI in learning, and documentation in the form of photographs, design results, and screenshots of the DeepAI use process. This participatory approach follows the recommendations of Kim (2024) and Ruiz Viruel et al. (2025) that the success of AI integration in education is largely determined by the social interaction, collaboration, and reflection that occur during learning.

Quantitative data analysis was conducted using descriptive statistics to measure the percentage increase in scores before and after model implementation. This analysis focused on comparing the average gain scores for creativity and digital literacy to determine the model's effectiveness. Qualitative data were analyzed using the interactive model of Albasry et al. (2025) through the stages of data reduction, data presentation, and conclusion drawing, with triangulation between sources (tests, observations, and interviews) to increase the validity of the results. Expert validation was conducted to ensure alignment between learning objectives, design strategies, media, and achieved outcomes based on the principle of constructive alignment (Rizqullah Pratama et al., 2025). This type of validation is also recommended by Bastidas et al., 2023 to avoid technocentric bias in the application of AI in educational contexts.

The research instruments included a TTCT-based creativity assessment rubric, a DigComp-based digital literacy questionnaire, a PjBL activity observation sheet, and an interview guide. All instruments were validated by three experts (two Educational Technology experts and one Craft expert), with a Content Validity Index (CVI) of 0.91, indicating a high level of suitability. This content validity is crucial to ensure that the instrument captures real changes in learners' creativity and digital literacy, as was also done in studies (M. Liu et al., 2025 and Markus et al., 2025).

All research procedures were conducted with adherence to educational research ethics, including written permission from the school, informed consent from participants, and the restriction of DeepAI's use to educational purposes only. The use of DeepAI was controlled to prevent visual plagiarism, misuse of the algorithm, or the production of non-educational content.

This ethical approach aligns with the AI in Education Ethics Framework guidelines proposed by Wang et al. (2024), which emphasizes the importance of algorithmic transparency and data protection in the implementation of AI technology in the classroom.

Thus, this research method is not only oriented towards developing a DeepAI integrated PjBL model, but also adopts the principles of ethical AI-based educational research to produce a learning model that is innovative, scientifically valid, and aligned with the 21st century human-centered learning paradigm.

RESULT

The implementation of the DeepAI-integrated digital PjBL model was conducted over three sessions on the topic "Processing Inorganic Waste into Creative Products." Each session represented the three main phases of PjBL as described by Larmer et al. (2015): Inquiry and Planning, Developing and Creating, and Reflecting and Presenting. This approach was chosen because it has proven effective in fostering engaged learning and authentic creativity, as evidenced by studies (Moundridou et al., 2024) and (Xia et al., 2025), which demonstrated that AI integration in PjBL can enhance learners' idea exploration, digital collaboration, and reflective awareness.

In the inquiry phase, learners were invited to identify various types of inorganic waste found in their environment and then discuss their potential uses as materials for creative projects. The DeepAI Image Generator application was used to generate visual ideas based on text descriptions they created, such as "recycled plastic flower vase with modern design." The use of AI helps expand the exploration of creative ideas and facilitates design imagination, as confirmed by Abrusci et al.'s (2025) findings that generative AI strengthens visual ideation in design-based projects. On this stage that AI can accelerate learners' cognitive visualization processes, as noted by Kong et al. (2024), highlighting AI's role as a cognitive amplifier in creative learning.

The developing and creating stage focuses on the process of designing and creating a concrete product. Learners work in groups to select materials, create a final design, and produce the work based on inspiration from DeepAI's output. The teacher acts as a facilitator, providing feedback on the relevance, originality, and neatness of the product design. This process demonstrates the synergy between AI-generated creativity and human design thinking, as suggested by Pedota et al.'s (2025) findings that human-AI interaction in project learning results in hybrid creativity, where the initial machine-generated ideas are reflectively adapted by humans. Throughout the process, learners expressed high enthusiasm for using DeepAI because the application helped visualize ideas that they would have struggled to express manually. These results align with research by Aprianto et al. (2023) that project-based learning integrating design thinking increases intrinsic motivation and originality of ideas.

The final stage, reflecting and presenting, was conducted through a mini digital exhibition, where learners displayed photos of their work, compared AI-generated ideas with handmade products, and wrote personal reflections on the differences between "machine products" and "human products." This activity strengthened participants' digital literacy and reflective awareness of their own creative thinking processes. Consistent with the findings of Kim (2024) and Ruiz Viruel et al. (2025), which confirmed that AI-driven project reflection can enhance learners' self-regulated learning and metacognitive awareness.

Field observations showed that most groups used AI not only as a visual aid but also as an ideation partner to explore more aesthetically pleasing design variations, color combinations, and material compositions. These findings reinforce the idea that AI can function as a co-creator in the learning process (Bahroun et al., 2023). Empirically, the collaborative relationship between AI and

learners results in creative co-production that enriches the learning experience. To measure the model's effectiveness, pretests and posttests were conducted on two main variables: creativity and digital literacy. The comparison results showed significant improvements in all measured aspects, as presented in Table 1.

Table 1. Comparison of Average Creativity and Digital Literacy

Measured Aspects	Pre-Intervention Mean	Post-Intervention Mean	Increase (%)
Product Creativity	67.40	84.10	24.8%
Idea Originality	65.20	83.40	27.9%
Digital Collaboration	70.80	87.30	23.3%
Digital Literacy	68.90	85.60	24.2%
Overall Average	68.10	85.10	25.0%

The product creativity aspect increased from 67.40 to 84.10 (a 24.8% increase), indicating that the integration of DeepAI in the ideation and design stages of the Craft project helped learners produce more innovative and aesthetically pleasing products. The highest increase occurred in idea originality (a 27.9% increase), indicating that AI visual stimuli expanded the space for divergent and reflective thinking. These results support the findings of Ruiz Viruel et al. (2025) that AI-mediated inquiry enhances divergent thinking skills in project-based learning.

The digital collaboration aspect increased from 70.80 to 87.30 (23.3% increase), reflecting learners' increased ability to collaborate in digital spaces using platforms such as Padlet, Google Classroom, and Canva. These findings reinforce the argument of X. Tan et al. (2025) that teacher orchestration in AI-based collaboration is a key factor in creating meaningful learning interactions. Meanwhile, digital literacy increased from 68.90 to 85.60 (24.2% increase), indicating a strengthening of learners' abilities to evaluate, manage, and produce digital content ethically and critically. Consistent with Bahroun et al. (2023), who asserted that AI-augmented PjBL strengthens learners' digital competencies through active engagement with intelligent technology.

Overall, the learning effect was very high with Cohen's d = 1.51 and an average increase of 25%. These results confirm that AI acts as a pedagogical catalyst, deepening project experiences and expanding learners' creative potential in the context of Craft learning. This finding supports Larmer et al.'s (2015) theory on the importance of reflection and revision stages enhanced by intelligent technology, and reinforces Ratniyom et al.'s (2025) view of deep learning competencies in 21st-century learning. Qualitative analysis through interviews and observations yielded four main themes: creative learning experiences, digital literacy, collaboration and motivation, and reflection and evaluation.

Table 2. Summary of Qualitative Findings from Teacher and Learner Interviews

Theme	Data Source	Representative Statement	Interpretation
Creative Learning Experience	Learners	"With DeepAI, we can find ideas for shapes and colors of plastic waste products more quickly."	DeepAI facilitates initial visual exploration of projects.
Digital Literacy	Teachers	"Students become accustomed to searching, verifying, and modifying design ideas online."	Critical digital thinking skills are enhanced.
Collaboration and Motivation	Learners	"We work in groups while discussing the AI-generated ideas and the handmade products."	AI encourages collaboration and curiosity.
Reflection & Evaluation	Teachers	"The children are more reflective because they can compare the AI results with their own work."	The reflective process is enhanced through comparison of results.

Qualitative findings show that the integration of DeepAI not only enriches the visual aspects but also expands the space for reflection, social interaction, and ethical awareness in learning. Teachers perceived AI as a co-creator that stimulates discussion of ideas, fosters collaborative responsibility, and deepens conceptual understanding. This aligns with the concept of deep learning by Ratniyom et al. (2025) and the results of a study (Wang et al., 2024), which states that meaningful learning occurs when learners are able to connect ideas, emotions, and actions within the context of authentic projects.

Overall, the results of this study confirm that the DeepAI-integrated PjBL model is effective in developing creativity and digital literacy and can serve as an empirical reference for AI-based pedagogical innovation in secondary schools in Indonesia.

DISCUSSION

The results of this study indicate that the integration of DeepAI into the Project-Based Learning (PjBL) model has a significant impact on improving learners' creativity and digital literacy. This improvement is evident not only in the quantity of products produced, but also in the quality of creative thinking, collaborative skills, and digital reflection. These findings align with the view (Bahroun et al., 2023), which asserts that generative artificial intelligence functions as an external cognitive tool that expands human thinking capacity through reflective human-machine interaction. In the context of Craft learning, DeepAI acts as a cognitive partner, assisting in the ideation, design, and evaluation of work, rather than simply as a visualization tool.

This phenomenon supports the constructivist principle proposed by Piaget (1972) and S. K. Kim et al. (2025), which states that knowledge is constructed through the active interaction of individuals with their environment. AI technology is now part of the learning environment, acting as a cultural mediator between ideas and representations. When learners provide prompts and receive visualizations from DeepAI, they indirectly engage in a reflective thinking cycle: evaluating the appropriateness of the AI's output, refining input, and revising ideas. This iterative process develops metacognitive awareness, as explained by Wang et al., 2024, who stated that active engagement in AI-augmented reflection can strengthen learners' higher-order thinking awareness.

The most prominent increase in idea originality in this study confirms AI's function as a catalyst for divergent thinking. Learners are encouraged to explore various possible ideas through AI visual stimuli, then adapt them to local contexts, such as waste materials available in the school environment. These results are consistent with the views of Runco & Jaeger (2012) and reinforced by Lee & Wu (2025), who found that AI-driven design tools enhance learners' ability to generate original and contextual ideas. Thus, human creativity remains at the core, while AI acts as a catalyst for idea exploration without diminishing its humanistic aspect.

In addition to expanding cognitive domains, the application of DeepAI also enhances digital literacy through idea exploration, online collaboration, and digital reflection. Learners learn to formulate effective prompts, evaluate visualization results, and select digital content appropriate for their projects. This aligns with the Digital Competence Framework for Educators (DigCompEdu) developed by Redecker & Punie (2017), which emphasizes the importance of ethical and productive use of technology to foster AI literacy and digital agency. The prompt engineering process in this study serves as a means of practicing critical thinking and decision-making based on visual data.

The application of Deep AI also strengthens the theory of Deep Learning in Education (Ratniyom et al., 2025). Deep learning occurs when learners connect ideas, values, and actions in

authentic contexts. Deep AI-based PjBL encourages learners to not only create products but also reflect on their thinking processes, collaborate digitally, and communicate their results openly. This aligns with the findings (Wang et al., 2024) that found AI-embedded learning environments can foster meaningful collaboration and knowledge transfer in real-world contexts.

From a national policy perspective, these findings support the direction of the National Curriculum (Kemendikbudsmen, 2025), which places creativity and digital literacy as two core competencies in the Graduate Profile. Deep AI-based Craft learning reflects the concrete implementation of the Freedom to Learn principle by providing space for independent exploration and reflection. The learning paradigm has shifted from "teaching with technology" to "learning with technology," as emphasized by Putra et al. (2022) and reinforced by Ruiz Viruel et al. (2025).

Theoretically, this research enriches the AI-mediated learning design model in the field of educational technology. Unlike the study by Putra et al. (2022), which solely emphasized the role of interactive digital media, this research introduces the concept of generative co-creation, where AI becomes an active co-creator in the learner's thinking and design process. This demonstrates a paradigm shift toward AI-enhanced pedagogy, where technology does not replace humans but instead enhances their cognitive capacities (Kong et al., 2024).

From an Instructional Design perspective, the integration of DeepAI into PjBL demonstrates a comprehensive implementation of the Dick, Carey, & Carey model, which emphasizes systemic alignment between objectives, strategies, and evaluation. DeepAI plays a role in the development phase of learning strategies as a medium that reinforces the principle of constructive alignment (Rizqullah Pratama et al., 2025). Every element of learning, from needs analysis to learning outcome assessment, supports each other to achieve measurable improvements in creativity and digital literacy.

Interview results support findings (J. Kim, 2024) regarding the importance of teacher orchestration in AI-based learning. Teachers act as reflective facilitators who help learners interpret AI output, assess the authenticity of ideas, and connect them to real-world contexts. Thus, the success of AI integration depends not only on technology but also on the teacher's pedagogical leadership in managing human-AI interactions.

This research also strengthens the Project-Based Learning theory formulated by Larmer, Mergendoller, & Boss (2015). Every stage, from driving questions to reflection and presentation, can be enriched through AI support. In the initial stage, DeepAI serves to stimulate learners' curiosity through visualization of ideas; in the process stage, AI provides rapid feedback on designs; and in the final stage, AI encourages reflection through comparisons between human and machine output. This approach expands the traditional concept of PjBL into AI-Enhanced Project-Based Learning, as also found in studies (Xia et al., 2025) and (Gao et al., 2025).

Empirically, the learning effect, with Cohen's d = 1.51, showed a significant 25% increase in creativity and digital literacy. This data supports the findings of Aprianto et al. (2023) that project-based learning with design thinking enhances original creativity and design reasoning. The results of this study add a new dimension in the form of the integration of AI as a visual feedback system that accelerates idea exploration and design revision.

From the perspective of social cognitive theory, these results are consistent with the concept of the Zone of Proximal Development (Vygotsky, 1978), where DeepAI functions as digital scaffolding that bridges the gap between learners' actual abilities and creative potential. AI provides cognitive support that enables learners to navigate the complexity of project ideas, transcending their initial capabilities, as described (Ruiz Viruel et al., 2025) and (Wang et al.,

2024). Furthermore, the collaborative interaction between participants and teachers reflects the principles of social constructivism, where meaning is constructed through negotiation and dialogue.

Thus, the DeepAI-integrated PjBL model developed in this study represents a hybrid pedagogical framework that combines social constructivism, project-based learning, and AI technology. Practically, this model provides guidance for teachers to implement AI-based PjBL ethically and contextually. Educational institutions are advised to develop AI policies that support learning innovation while maintaining academic integrity and digital ethics.

Conceptually, these findings reinforce the direction of Education 5.0, where the collaboration between humans and AI not only increases efficiency but also enriches the human dimension of education. With a reflective and purposeful approach, AI is not a substitute for human creativity, but rather a strategic partner in creating more innovative, contextual, and meaningful learning.

CONCLUSSION

This research produces a digital Project-Based Learning model integrated with DeepAI technology that has been proven effective in improving students' creativity and digital literacy. This model was developed through a Research and Development approach based on Dick, Carey & Carey's instructional design and implemented in Craft learning with the support of the Deep Learning for Deep Learners principle (Ratniyom et al., 2025). Empirical results show an average increase of 25% in creativity and digital literacy, with the highest increase in the aspect of originality of ideas, indicating that AI plays a role not just as a visual aid, but as a cognitive partner that stimulates divergent, reflective, and collaborative thinking processes. Theoretically, these results strengthen the relevance of constructive alignment (Rizqullah Pratama et al., 2025), and expand the concept of instructional scaffolding (Vygotsky, 1978) into digital scaffolding, where AI helps learners reach their zone of proximal development through visual inspiration and automatic reflection. Practically, DeepAI-integrated PjBL provides a contextual learning framework aligned with the National Curriculum (Kemendikdasmen, 2025) and supports the strengthening of learner profiles that are creative, collaborative, and critical thinkers. Theoretically and practically, this research contributes to the development of AI-enhanced instructional design in the realm of Educational Technology and opens up opportunities for further studies related to the development of AI-based feedback systems, cross-subject applications, and exploration of adaptive Deep Learning to strengthen learners' metacognitive abilities towards an AI for Learning ecosystem that is ethical, collaborative, and oriented towards human values.

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