Formosa Journal of Science and Technology (FJST)
Vol. 5, No. 5, 2026: 1235-1250

Integration of Generative Artificial Intelligence in Project Based Learning to Enhance Higher Order Thinking Skills of University Students in the Society 5.0 Era

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A R T I C L E I N F O

Keywords: Generative Artificial Intelligence, Project Based Learning, Higher Order Thinking Skills, Society 5.0, Higher Education.

Received : 27, March
Revised : 29, April
Accepted: 30, May

A B S T R A C T

This study aims to explore the integration of Generative Artificial Intelligence (GenAI) in Project Based Learning (PBL) to support the development of students' Higher Order Thinking Skills (HOTS) in the Society 5.0 era. The research uses a qualitative approach with a case study design on project-based learning in college. The research informants consisted of 18 students and 4 lecturers who were selected purposively based on their involvement in the use of GenAI in the learning process. Data were collected through in-depth interviews, observations, documentation, and Focus Group Discussions (FGDs), then analyzed using thematic analysis. The results show that the integration of GenAI in PBL supports students' analytical thinking skills, creativity, critical reflection, and collaboration through more adaptive and interactive learning. This study concludes that the use of GenAI in PBL has the potential to be an innovative learning strategy to strengthen students' HOTS in the Society 5.0 era

ISSN-E: 2964-6804
DOI: https://doi.org/10.55927/fjst.v5i5.69
https: https://journalfjst.my.id/index.php/fjst

INTRODUCTION

The development of digital technology in the Society 5.0 era has driven a major transformation in the higher education system, especially in the use of artificial intelligence as part of learning innovation. Society 5.0 emphasizes the integration between intelligent technology and human life to create a human-centered society with the support of adaptive and sustainable digital technologies. In the context of higher education, this transformation requires universities to not only focus on knowledge transfer, but also on the development of students' Higher Order Thinking Skills (HOTS) which include critical thinking, creativity, problem-solving, and collaboration skills (UNESCO, 2023). These skills are important competencies in facing the challenges of the world of work and technology-based social dynamics in the 21st century.

One of the technological developments that is currently widely integrated in education is Generative Artificial Intelligence (GenAI), such as ChatGPT, Gemini, and various other generative AI-based platforms. This technology is able to produce texts, ideas, simulations, and recommendations that can support the learning process to be more interactive and personalized. According to research conducted by Kasneci et al. (2023), the use of GenAI in education has the potential to increase learning engagement, support student creativity, and expand access to digital learning resources. In addition, the OECD report (2024) shows that the use of AI in higher education continues to increase globally because it is considered to be able to support active and adaptive learning according to the needs of students in the digital era.

In Indonesia, the implementation of AI technology in higher education is also starting to grow in line with the acceleration of digital transformation after the pandemic. Universities are starting to use AI to support online learning, academic evaluation, and the development of technology-based projects. However, the learning process in many universities still tends to be teacher-centered learning and has not fully encouraged the optimal development of student HOTS. This condition causes students to often experience difficulties in developing analytical, reflective, and problem-solving skills in project-based learning. Therefore, an innovative learning approach is needed that is able to integrate AI technology with active learning models such as Project Based Learning (PBL).

Project Based Learning is a constructivistic learning model that places students as the center of learning through the collaborative completion of real projects. This model is considered effective in improving high-level thinking skills because students are encouraged to explore problems, develop solutions, and produce learning products independently. Research by Anazifa and Djukri (2021) shows that PBL has a positive influence on students' critical thinking skills and creativity. In addition, a study by Rahman et al. (2022) explains that the integration of digital technology in PBL can increase students' active participation as well as strengthen collaborative skills in 21st century learning.

However, research on the integration of Generative Artificial Intelligence in Project Based Learning is still relatively limited, especially in the context of higher education in Indonesia. Most previous research has focused more on the

effectiveness of AI in general learning or the use of PBL separately without integrating GenAI technology in depth. Research by Zawacki-Richter et al. (2021) emphasizes the use of Artificial Intelligence in personalizing learning, while Cotton et al.'s (2023) research focuses on the ethical challenges of using ChatGPT in higher education. On the other hand, research related to PBL has more discussed improving collaboration skills and creativity without examining how generative AI can shape a more adaptive and reflective learning experience. This condition shows that there is a research gap related to the integration of GenAI in PBL to support the development of student HOTS in the Society 5.0 era.

In addition to the conceptual research gap, there are still limitations in research that uses a qualitative approach to understand the experience of students and lecturers in the use of GenAI in project-based learning. Most previous studies have used a quantitative approach that focuses on measuring learning outcomes, so there has not been much exploration of the dynamics of interactions, perceptions, and learning processes that occur during the integration of AI in PBL. In fact, a qualitative approach is important to understand how AI technology affects students' thinking patterns, critical reflection, and collaborative experiences in the context of real learning.

Based on these problems, this study aims to explore the integration of Generative Artificial Intelligence in Project Based Learning to support the development of students' Higher Order Thinking Skills in the Society 5.0 era. This research specifically focuses on how the use of GenAI shapes students' learning experiences, improves analytical and creative thinking skills, and supports collaboration and problem-solving processes in project-based learning in college.

This research is expected to make a theoretical contribution to the development of technology-based education studies, especially related to the integration of Generative Artificial Intelligence and Project Based Learning in strengthening student HOTS. In addition, this research also provides practical contributions for lecturers, higher education institutions, and education policy developers in designing innovative learning strategies that are adaptive to technological developments in the Society 5.0 era. The results of the research are expected to be the basis for the development of AI-based learning models that are more human-centered, collaborative, and relevant to the learning needs of the 21st century.

THEORETICAL REVIEW

Generative Artificial Intelligence in Higher Education Transformation

Generative Artificial Intelligence (GenAI) is one of the technologies that is increasingly influencing the direction of higher education transformation because of its ability to generate texts, ideas, feedback, simulations, and learning support in an adaptive manner. In the context of Society 5.0, GenAI is not only understood as a technical tool, but also as part of a learning ecosystem that connects intelligent technology with human capacity development. UNESCO (2023) emphasized that the use of GenAI in education needs to be directed to human-centered principles, namely technology must strengthen the role of lecturers and students, not replace human thinking processes. Thus, the

integration of GenAI in higher education learning must be designed pedagogically to be able to support student learning independence, creativity, critical reflection, and problem-solving.

Kasneci et al.'s (2023) study shows that large language models such as Chat GPT have great opportunities in education, especially to support personalized learning, providing feedback, finding ideas, and strengthening access to information. However, the use of GenAI also presents challenges in the form of student dependence, information bias, answer hallucinations, and academic integrity issues. Cotton, Cotton, and Shipway (2023) assert that the use of ChatGPT in higher education should be associated with more authentic assessment designs so that students not only produce academic products, but also demonstrate responsible thinking processes. Therefore, the integration of GenAI in learning needs to be combined with active pedagogical models such as Project Based Learning so that technology really becomes a scaffolding for the development of Higher Order Thinking Skills.

Project Based Learning as a Constructivistic Approach

Project Based Learning (PBL) is a constructivism-based learning approach that places students as active subjects in building knowledge through the completion of real projects. In PBL, students not only receive information from lecturers, but also identify problems, design solutions, collect data, compile products, and reflect on the learning process. This approach is relevant to higher education needs because it encourages students to connect theory with practice as well as develop collaborative skills in situations that resemble real-world contexts.

Research on PBL shows that this model has the potential to improve critical thinking, creativity, communication, and problem-solving skills. PBL provides space for students to experience complex learning processes, starting from analyzing problems, evaluating alternative solutions, to creating new products or ideas. Recent studies on PBL and HOTS emphasize that project-based learning can strengthen higher-level thinking skills because students are engaged in learning activities that require analysis, evaluation, and creation, rather than just remembering concepts.

Higher Order Thinking Skills in Education Era Society 5.0

Higher Order Thinking Skills (HOTS) refers to the ability to think at a higher level that includes analysis, evaluation, creativity, problem-solving, and decision-making. In higher education, HOTS is an important competency because students are required to be able to face complex problems, work collaboratively, and use technology critically and ethically. In the era of Society 5.0, mastery of technology alone is not enough; Students also need to have the reflective ability to assess information, develop innovative solutions, and understand the social impact of the use of technology.

The integration of HOTS in learning demands a shift from passive learning to active and reflective learning. GenAI can support HOTS when used as a tool to expand the exploration of ideas, compare points of view, formulate critical questions, and evaluate alternative solutions. However, GenAI can also weaken HOTS if students use it as a shortcut to generate answers without deep thinking. Zhao et al. (2025) through a meta-analysis of 29 experimental and quasi-

experimental studies showed that GenAI has positive potential for higher-order thinking, but its effectiveness is highly dependent on learning design, lecturer guidance, and how students use the technology.

Gen AI Integration in Project-Based Learning

The integration of GenAI in PBL can be understood as a learning strategy that combines the power of generative technology with collaborative and problem-based project activities. In the PBL process, GenAI can be used by students to find inspiration, formulate problems, develop project frameworks, develop alternative solutions, evaluate ideas, and reflect on the results of their work. Thus, GenAI is not placed as a substitute for students' thinking abilities, but as a learning partner that helps expand cognitive and metacognitive processes.

Fitriyah and Ratnawati's (2025) research shows that the use of GenAI in project-based learning in higher education is related to the role of lecturers, implementation challenges, and pedagogical strategies used during learning. These findings indicate that the success of GenAI integration is not only determined by the availability of technology, but also by the ability of lecturers to design learning activities, guide the use of AI, and ensure students remain engaged in the critical thinking process. Another study by Alim (2025) also showed that AI-assisted Project Based Learning can support students' critical thinking skills, especially when the technology is used within a clear project task framework.

The Role of Lecturers, Academic Ethics, and AI Literacy

In the integration of PBL-based GenAI, lecturers have an important role as facilitators, directors, and guardians of academic ethics. Lecturers need to ensure that students understand the limits of GenAI's use, are able to verify the information generated by AI, and still demonstrate the contribution of original thinking in the project. This is important because GenAI can generate information that seems convincing, but is not necessarily accurate. UNESCO (2023) emphasizes the need for policies, AI literacy, and institutional capacity for GenAI to be used safely, ethically, and responsibly in education.

AI literacy is an integral aspect of HOTS because students need to understand how AI technology works, potential, and limitations. Song et al. (2025) found that GenAI-based learning strategies can improve students' HOTS and AI literacy if their use is directed through interactive strategies and adequate supervision. These findings reinforce the argument that GenAI is not enough to be introduced as a digital tool, but needs to be integrated into learning designs that train students to question, evaluate, revise, and critically reflect on the results of their work.

Research Gap and Research Position

Previous studies have discussed PBL as an active learning strategy and GenAI as a technological innovation in higher education. However, most studies still address the two separately. Research on PBL generally focuses on the effectiveness of models on learning outcomes, critical thinking skills, or creativity, while research on GenAI focuses more on opportunities, challenges, academic ethics, and personalization of learning. There are still limited studies

that specifically explore how GenAI is integrated in the PBL stage to support the development of student HOTS in the context of Society 5.0.

In addition, most studies on GenAI and HOTS still use quantitative approaches to measure the influence or effectiveness of learning. In fact, a qualitative approach is needed to understand the experience of students and lecturers in more depth, especially related to how GenAI is used in the process of exploring ideas, collaboration, critical reflection, and project completion. Therefore, this research occupies an important position by exploring the integration of GenAI in PBL as a complex, contextual, and development-oriented learning experience of students' HOTS.

Conceptual Framework of Literature Review

Based on a literature review, the integration of GenAI in PBL can be understood through the relationship between technology, pedagogy, and the development of high-level thinking competencies. GenAI acts as a cognitive tool that supports the search for ideas, the preparation of alternative solutions, and learning reflection. PBL acts as a pedagogical framework that directs students to solve real problems through project activities. Meanwhile, HOTS is the main learning achievement that includes analytical, creative, reflective, and collaborative thinking skills. In the context of Society 5.0, the relationship between these three elements shows that educational technology must be directed to strengthen human capacity, not just accelerate the production of academic tasks.

METHODOLOGY

Design and Research Approach

This study uses a qualitative approach with a case study design to explore the integration of Generative Artificial Intelligence (GenAI) in Project Based Learning (PBL) to support the development of students' Higher Order Thinking Skills (HOTS) in the Society 5.0 era. The qualitative approach was chosen because the research focuses on an in-depth understanding of students' experiences, perceptions, and learning processes in the use of AI technology in project-based learning (Creswell & Creswell, 2023).

Population and Research Participants

The research was carried out at one of the universities in Indonesia that implements project-based learning assisted by digital technology. The research population consists of students and lecturers who are involved in the implementation of Project Based Learning using Generative Artificial Intelligence. The sampling technique uses purposive sampling because participants are selected based on their direct experience in using GenAI during the learning process. The research participants consisted of 18 students and 4 lecturers who actively used generative AI in project-based learning activities. This number is considered adequate because it has achieved data saturation in qualitative research (Braun & Clarke, 2022).

Data Collection Techniques

Data collection was carried out through in-depth interviews, participatory observations, documentation, and Focus Group Discussions (FGDs). Semi-structured interviews were used to explore the experiences and perceptions of

students and lecturers regarding the use of GenAI in learning. Observations were made to observe collaboration activities, problem-solving, and the use of AI during the project work process. Documentation in the form of project reports, learning notes, and student reflection results is used as supporting data. The research instruments were compiled based on the concepts of HOTS, constructivistic learning, and the integration of AI in higher education (Kasneci et al., 2023).

The validity of the data is carried out through source triangulation, triangulation techniques, and member checking to ensure the credibility and consistency of research results (Lincoln & Guba, 2021).

Research Procedure

The research is carried out through several stages, namely problem identification, literature study, preparation of research instruments, field data collection, implementation of interviews and FGDs, data analysis, and drawing conclusions. Data collection is carried out during the project-based learning process that takes place in one academic semester.

Data Analysis Techniques

Data were analyzed using thematic analysis techniques through the stages of data reduction, coding, theme categorization, interpretation of meaning, and drawing conclusions (Braun & Clarke, 2022). The analysis was conducted to identify the pattern of student experience related to the development of HOTS through the integration of GenAI in PBL. This study uses the help of NVivo 14 software to support the coding process and systematic data organization (Paulus & Lester, 2022).

RESEARCH RESULTS

The results of the study show that the integration of Generative Artificial Intelligence (GenAI) in Project Based Learning (PBL) has an influence on the development of students' Higher Order Thinking Skills (HOTS), especially in the aspects of analytical thinking, creativity, critical reflection, collaboration, and problem solving. The findings were obtained through in-depth interviews, participatory observations, project documentation, and Focus Group Discussions (FGD) conducted during the period February–April 2026 with students and lecturers involved in generative AI-assisted project-based learning.

Strengthening Analytical Thinking Skills

The results of the interviews show that students use GenAI to help identify project problems, develop a framework of thinking, and compare alternative solutions more systematically. Students revealed that AI helps them understand project topics that were previously considered complex. One of the students said:

"*At first I was confused about where to start because the topic was quite broad. When I tried to use ChatGPT, I was able to get an idea of the flow of the problem first. From there, I can think in more detail*." (MHS-03/Interview/February 18, 2026)

Other students also explained that the use of AI helps the analysis process to be faster, especially when looking for relationships between concepts in a project.

"*Usually, if you look for manual references, it takes a long time because you have to open many journals one by one. With AI, I can get an initial summary first, so it's easier to determine the focus of the analysis*." (MHS-11/Interview/February 22, 2026)

The lecturer who teaches the course also observed changes in the mindset of students during project-based learning.

"*Students seem to understand the structure of the problem faster. They are no longer too long in the initial confusion stage because AI helps lure their thinking direction*." (DSN-02/Interview/February 25, 2026)

However, observations show that some students are still more likely to receive AI answers directly without further exploration.

"*Sometimes I trust AI answers too much because they seem to be complete. But after checking again, it turned out that there were some parts that were not in accordance with the context of our project*." (MHS-07/Interview/March 1, 2026)

Creativity and Project Idea Development

The findings of the study show that GenAI helps students in exploring more varied and innovative project ideas. Students use AI to seek design inspiration, simulate ideas, draft presentations, and develop alternative solutions to project problems.

Based on class observations from March 3–15, 2026, the group that actively used GenAI showed a wider variety of project ideas than the group that used conventional search methods. One of the students explained:

"*Usually our project ideas are monotonous because the references are just that. But when we use AI, we get a lot of new perspectives that we didn't think of before*." (MHS-15/Interview/March 5, 2026)

Another student revealed that AI helped give rise to the courage to try more creative concepts.

"*I became more confident in developing ideas because AI gave me alternative examples. So I don't feel afraid of the wrong time to brainstorm*." (MHS-08/Interview/March 7, 2026)

Lecturers also observed changes in the quality of presentations and student project results.

"*This year's student project products are more diverse. They are more exploratory in creating concepts because there is AI support to help visualization and idea development*." (DSN-01/Interview/March 10, 2026)

However, it was also found that some students were too dependent on AI-generated ideas.

"*Sometimes we focus too much on AI recommendations that we forget to develop our own ideas. So lecturers often remind me that AI is only a tool*." (MHS-12/Interview/March 12, 2026)

Critical Reflections on AI Information

The results showed that students began to develop critical reflection skills while using GenAI in project-based learning. Most students realize that AI-generated information needs to be verified using other academic sources before it is used in projects. One of the students said:

"*At first I thought all the AI answers were correct. But it turns out that there is data that is not appropriate when checked again in the journal. So now I always cross-check first*." (MHS-01/Interview/March 15, 2026)

Another student revealed:

"*AI does help quickly, but if it is used immediately without checking it again, it can also be dangerous because sometimes the references are not clear*." (MHS-09/Interview/March 18, 2026)

The results of observations during the group discussions showed that students began to get used to comparing AI results with scientific journals and other reliable sources before making decisions on projects.

Lecturers also provide assessments related to changes in student reflection patterns.

"*Students who were initially passive began to look more critical when asked to account for information from AI. They learn that technology still needs to be validated*." (DSN-03/Interview/March 20, 2026)

However, not all students show the same level of critical reflection.

"*When the deadline is close, sometimes we immediately use AI answers without checking too deeply because we are chasing time*." (MHS-14/Interview/March 22, 2026)

The Dynamics of Collaboration in Project-Based Learning

The results of the observation show that GenAI integration strengthens the student collaboration process during the project work. Students are more active in discussing the results of AI outputs and making joint revisions based on the results of the exploration of ideas obtained. One of the students explained:

"*Usually the group discussion is long in the initial brainstorming. Now it's faster because AI helps you get an idea first, so we just have to discuss the development*." (MHS-04/Interview/March 25, 2026)

Another student said that the use of AI helps groups work more efficiently.

"*The division of tasks becomes clearer because AI helps to outline the project. So we're not too confused about where to start*." (MHS-16/Interview/March 27, 2026)

However, some lecturers observed changes in student interaction patterns.

"*There are groups that are too focused on AI so that communication between members is a little reduced. So sometimes they are busy with their own devices*." (DSN-04/Interview/March 29, 2026)

The observational findings also showed that groups with good levels of interpersonal communication tended to be able to use AI more effectively than groups with low communication.

Learning Adaptation in the Society Era 5.0

Most students view the integration of GenAI in PBL as a form of learning that is relevant to the needs of the digital world of work in the Society 5.0 era. Students feel that the use of AI helps them understand how technology can be used to support problem solving productively and adaptively. One of the students said:

"*I think learning like this is more realistic because now the world of work has also used a lot of AI.*" (MHS-05/Interview/April 2, 2026)

Another student revealed:

"*We learned not only to use technology, but also how to use technology correctly*." (MHS-10/Interview/April 4, 2026)

The lecturer also assessed that the integration of AI makes learning more contextual with current technological developments.

"*Students look more enthusiastic because they feel that this learning is close to the digital reality they face every day*." (DSN-01/Interview/April 6, 2026)

However, some students expressed concerns about the reliance on AI.

"*If I use AI too often, I'm afraid I'll be lazy to think for myself*." (MHS-17/Interview/April 8, 2026)

"*AI does help, but if everything is left to AI, our analytical capabilities can decline*." (MHS-06/Interview/April 9, 2026)

DISCUSSION

The results of the study show that the integration of Generative Artificial Intelligence (GenAI) in Project Based Learning (PBL) contributes positively to the development of students' Higher Order Thinking Skills (HOTS), especially in analytical thinking skills, creativity, critical reflection, collaboration, and problem solving (Dwivedi et al., 2023; Kasneci et al., 2023). This finding can be seen from how students use GenAI to understand project problems, develop a framework of thinking, develop alternative solutions, and validate information through discussions and other academic sources. Conceptually, these findings are in line with the PBL principle which places students as active subjects in learning through exploration of real problems, collaborative work, and project-based solution production (Kokotsaki et al., 2016). In this context, GenAI acts as a cognitive scaffold, which is a cognitive tool that accelerates the initial exploration process, broadens perspectives, and helps students build more systematic thought structures (Luckin & Holmes, 2021).

Improving analytical thinking skills is one of the main findings. Students are no longer completely dependent on lecturer explanations or manual reference searches, but are starting to use GenAI to parse problems, find relationships between concepts, and compare alternative solutions. This supports the view that AI technology can strengthen the learning process when used to encourage reasoning, rather than simply to produce final answers (Zawacki-Richter et al., 2019). UNESCO (2023) emphasizes that GenAI in education needs to be directed to empower learners and educators through a human-centered approach, including through knowledge validation and critical capacity building. Thus, the important significance of these findings is that GenAI can accelerate the early stages of understanding problems in PBL, but the quality of HOTS remains dependent on students' ability to test, interpret, and develop AI outputs independently.

The findings on creativity show that GenAI helps students generate a wider variety of project ideas. Students get design inspiration, alternative solutions, and more diverse presentation concepts. This reinforces the assumption that creativity

in project-based learning arises not only from individual abilities, but also from interactions between students, technology, and the context of the problem (Henriksen et al., 2021). However, the study also found the risk of homogenizing ideas when students overfollow AI recommendations without critical modification. The findings are in line with recent studies showing that GenAI can improve high-level thinking skills, especially problem-solving and critical thinking, but its impact on creativity can be limited if learners only reproduce machine-generated ideas (Baidoo-Anu & Owusu Ansah, 2023). This means that GenAI is more appropriately positioned as an idea trigger, rather than a single source of creativity.

The aspect of critical reflection is also an important contribution to this research. College students are beginning to realize that AI answers are not always accurate and need to be verified through journals, books, or other scientific sources. This awareness shows the development of AI literacy, which is the ability to use, evaluate, and control AI technology responsibly (Long & Magerko, 2020). These findings are relevant to the OECD report which emphasizes that the development of AI requires education to revisit what skills need to be prioritized, especially critical thinking skills, human judgment, and understanding of technological limitations (OECD, 2021). Thus, the integration of GenAI in PBL not only impacts project outcomes, but also shapes students' epistemic awareness that digital information should be tested before being used as a basis for academic decision-making.

In terms of collaboration, GenAI helps groups work more efficiently, especially in compiling outlines, dividing tasks, and speeding up the brainstorming process. However, the findings also show that not all groups experience an equal increase in collaboration. Groups with good interpersonal communication tend to be able to utilize AI more productively, while groups with less communicative risk making AI the center of activity so that interaction between members decreases. This shows that the success of GenAI integration in PBL is not only determined by the availability of technology, but also by learning design, lecturer roles, group dynamics, and academic discussion culture (Holmes et al., 2022).

The findings of this study also have an important meaning in the context of Society 5.0. Students consider GenAI-assisted project-based learning to be more relevant to the needs of the digital world of work because they not only learn to complete academic assignments, but also learn to use technology to support problem-solving. The contribution of this research lies in strengthening the understanding that HOTS in the AI era is not only understood as the ability to think analytically and creatively in a conventional way, but also includes the ability to validate information, manage technological assistance, maintain the originality of ideas, and use AI ethically (Aoun, 2017). In other words, HOTS in modern learning needs to be expanded into critical-technological thinking skills.

However, the study also found several obstacles. First, some students still show dependence on AI, especially when facing time pressure or project deadlines. Second, not all students have adequate prompt engineering and resource literacy skills. Third, there is a risk of using unvalidated information if the

lecturer does not provide clear directions. Recent systematic studies also show that students often experience challenges in evaluating GenAI outputs and facing ethical issues such as academic integrity, privacy, and data security (Cotton et al., 2023; Tlili et al., 2023). Therefore, GenAI integration in PBL needs to be accompanied by usage guidelines, thought process evaluation rubrics, source verification obligations, and written reflections on how AI is used in projects.

Based on this analysis, further research is recommended to use a quasi-experimental design or mixed methods so that the impact of GenAI on HOTS can be measured more strongly through pre-test and post-test. The next study can also compare the GenAI-assisted PBL group and the conventional PBL group, test the role of AI literacy as a moderator variable, and develop a HOTS evaluation instrument that includes aspects of analysis, evaluation, creativity, ethics of using AI, and metacognitive reflection. In addition, future research needs to involve a larger number of participants, cross-curricular studies, and longer implementation durations for more generalized results.

CONCLUSIONS AND RECOMMENDATIONS

This study shows that the integration of Generative Artificial Intelligence (GenAI) in Project Based Learning (PBL) contributes positively to the development of students' Higher Order Thinking Skills (HOTS) in the Society 5.0 era, especially in the aspects of analytical thinking, creativity, critical reflection, collaboration, and problem solving. The use of GenAI helps students accelerate the exploration of ideas, understand the structure of problems more systematically, and support a more adaptive and contextual learning process with the needs of the digital workforce. In addition, the integration of AI in project-based learning encourages students to start developing AI literacy and evaluative abilities towards digital information. These findings reinforce the view that GenAI can function as a cognitive scaffold that supports high-level thinking processes when used in a pedagogical, reflective, and human-centered manner. However, the study also found a risk of dependence on AI, a decrease in the exploration of original ideas, and the use of information that has not been validated when students do not verify critically.

Based on these results, universities and lecturers are advised to develop AI-based learning strategies that are not only oriented towards the use of technology, but also on strengthening academic ethics, AI literacy, and critical reflection of students. The integration of GenAI in PBL needs to be accompanied by guidelines for the use of AI, authentic assignment design, thought process-based assessment rubrics, and academic resource validation activities so that students remain actively involved in the analysis and decision-making process. In addition, lecturers need to play the role of facilitators who direct the use of AI proportionately so that technology does not replace students' thinking skills, but rather strengthens their intellectual and collaborative capacity. Further research is recommended to use a mixed methods or quasi-experimental approach with a wider scope of participants so that the effectiveness of GenAI integration in the development of HOTS can be tested more comprehensively and generally.

FURTHER STUDY

The next research is suggested to develop a study on the integration of Generative Artificial Intelligence (GenAI) in Project Based Learning (PBL) through a mixed methods or quasi-experimental approach so that the influence of the use of AI on Higher Order Thinking Skills (HOTS) can be measured more comprehensively through qualitative and quantitative data. Future research may also involve larger numbers of participants, across courses of study, and different levels of college to obtain more generalized results. In addition, subsequent studies need to explore other variables such as AI literacy, self-regulated learning, technology readiness, learning motivation, and academic ethics as factors that can affect the effectiveness of GenAI integration in project-based learning. Research related to the development of AI-based HOTS evaluation models and pedagogical strategies to minimize students' dependence on AI is also important to be carried out in the context of higher education in the era of Society 5.0.

ACKNOWLEDGMENT

The author expressed his gratitude to all students and lecturers who have participated in this research and provided experiences, views, and reflections during the data collection process. Appreciation was also expressed to higher education institutions that have supported the implementation of research, especially in the implementation of project-based learning assisted by digital technology. Thank you to all parties who have helped the observation process, interviews, Focus Group Discussion (FGD), and the preparation of this research so that the research can be completed properly.

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