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Artificial Intelligence-Assisted Science Learning: Exploring the Development of Inventive Thinking among Higher Education Students

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Abstract
Artificial Intelligence (AI) has emerged as a transformative technology in science education by enhancing learning experiences, supporting inquiry-based instruction, and promoting higher-order thinking skills. Despite its growing integration into educational settings, limited qualitative research has examined how AI-assisted learning influences the development of inventive thinking among higher education students. This study explored how Artificial Intelligence-assisted science learning influences the development of inventive thinking among higher education students. Guided by Constructivist Learning Theory and Social Constructivism, the study employed an exploratory qualitative research design. Twenty-five (25) purposively selected undergraduate students enrolled in science-related programs participated in semi-structured interviews. The collected narratives were analyzed using Reflexive Thematic Analysis. The findings revealed that AI-assisted science learning enhances students' conceptual understanding and provides continuous learning support through immediate feedback and personalized learning experiences. Moreover, AI fosters creative exploration, strengthens scientific problem-solving, stimulates idea generation, and supports the development of innovation skills by encouraging learners to evaluate multiple perspectives and refine scientific solutions. The study concludes that Artificial Intelligence serves as a complementary educational resource that promotes inventive thinking without replacing learners' creativity, critical thinking, or scientific reasoning. The findings highlight the importance of integrating AI-assisted learning into science education through learner-centered and inquiry-based instructional approaches that prepare students for innovation and scientific problem-solving in the digital era..
Keywords : Artificial Intelligence-assisted learning, inventive thinking, science education, higher education, qualitative research, innovation.

Introduction

Artificial Intelligence (AI) is rapidly transforming science education by reshaping how students acquire knowledge, solve problems, and engage in scientific inquiry. AI-assisted learning technologies, including intelligent tutoring systems, generative AI applications, adaptive learning platforms, and virtual laboratory assistants, have expanded opportunities for personalized instruction, immediate feedback, and inquiry-based learning. Rather than serving merely as information retrieval tools, these technologies support learners in analyzing scientific concepts, exploring alternative solutions, and constructing knowledge through interactive learning experiences. As AI becomes increasingly integrated into educational settings, it has also begun to influence higher-order thinking skills such as creativity, innovation, and inventive thinking, which are considered essential competencies for learners in the twenty-first century (UNESCO, 2023; Dwivedi et al., 2023).

The growing integration of Artificial Intelligence into education coincides with global efforts to strengthen science learning and innovation. Contemporary science education extends beyond the acquisition of scientific knowledge to emphasize problem-solving, creativity, critical thinking, and the application of scientific concepts to authentic situations (Samodra et al., 2026). Students are expected not only to understand scientific principles but also to investigate problems, design innovative solutions, and generate new knowledge through inquiry and experimentation. These competencies have become increasingly important as societies confront complex

environmental, technological, and industrial challenges that require scientific innovation and interdisciplinary collaboration (Ng et al., 2026; Patel et al., 2024).

Despite these educational priorities, international assessments continue to indicate persistent challenges in science education. According to the Programme for International Student Assessment (PISA) 2022, only approximately 23% of Filipino learners achieved at least Level 2 proficiency in science, substantially lower than the Organisation for Economic Co-operation and Development (OECD) average of 76% (OECD, 2023). These findings suggest that many students continue to experience difficulties in interpreting scientific information, applying scientific reasoning, and solving real-world problems. Bernardo et al. (2023) similarly reported that Filipino learners remain challenged in developing the scientific literacy and higher-order cognitive skills necessary for effective participation in knowledge-driven societies. Such findings highlight the continuing need to strengthen science instruction by cultivating learning environments that promote curiosity, creativity, inquiry, and inventive thinking.

Inventive thinking has emerged as one of the defining competencies of contemporary science education because it enables learners to generate original ideas, adapt knowledge to unfamiliar situations, and develop innovative solutions to complex scientific problems. Ng et al. (2026) described inventive thinking as an integration of creativity, critical thinking, problem-solving, curiosity, and self-regulation that enables individuals to respond effectively to novel situations. Likewise, Garner et al. (2021) emphasized that invention education provides learners with opportunities to explore ideas, develop scientific identities, and cultivate confidence through authentic problem-solving experiences. These perspectives suggest that inventive thinking is not an isolated cognitive ability but a developmental process supported by meaningful instructional experiences and innovation-oriented learning environments.

Artificial Intelligence-assisted learning offers new possibilities for fostering inventive thinking by providing students with personalized learning pathways, immediate feedback, and opportunities to explore multiple approaches to scientific problems. Recent studies suggest that AI-supported educational environments enhance learners' engagement, encourage inquiry, and facilitate deeper conceptual understanding by adapting instruction to students' individual learning needs (Ahmed, 2025; Shehata et al., 2024). Similarly, AI-assisted technologies enable students to simulate scientific investigations, visualize abstract concepts, and receive continuous guidance throughout the learning process, creating conditions that support creativity and innovation. However, while these technologies offer significant instructional advantages, their effectiveness depends largely on how learners actively interact with AI as a learning partner rather than relying on it solely as an answer-generating tool (UNESCO, 2023).

Educational theories further explain why AI-assisted learning may contribute to the development of inventive thinking. Constructivist Learning Theory posits that learners actively construct knowledge through meaningful experiences rather than passively receiving information (Chen & Tsai, 2021). Complementing this perspective, Social Constructivism emphasizes that knowledge develops through interaction, collaboration, and shared problem-solving within authentic learning environments (Shehata et al., 2024). Artificial Intelligence-assisted learning aligns with these theoretical perspectives by providing interactive learning experiences that encourage exploration, reflection, and collaborative inquiry while supporting learners in constructing scientific understanding through continuous feedback and guided discovery.

Although previous studies have extensively examined innovative teaching practices, inquiry-based learning, creativity, and inventive thinking in science education (Fuad et al., 2022; Ou et al., 2024; Samodra et al., 2026), limited qualitative research has explored how Artificial Intelligence-assisted science learning influences the development of inventive thinking among higher education students. Existing investigations have primarily focused on instructional strategies, institutional culture, and classroom environments without considering the growing role of AI-assisted learning technologies in shaping students' creative and innovative capacities. As Artificial Intelligence continues to transform educational practice, understanding students' experiences with AI-assisted science learning becomes increasingly important for designing instructional environments that promote innovation, scientific inquiry, and higher-order thinking.

Guided by Constructivist Learning Theory and Social Constructivism, the present study seeks to explore how Artificial Intelligence-assisted science learning influences the development of inventive thinking among higher education students. The findings are expected to contribute to the growing discourse on Artificial Intelligence in

science education by providing qualitative insights into how AI-assisted learning supports inventive thinking and innovation-oriented competencies within higher education.

Methods

Research Design

This study employed an exploratory qualitative research design to examine how Artificial Intelligence-assisted science learning influences the development of inventive thinking among higher education students. An exploratory qualitative approach was appropriate because it enabled an in-depth understanding of students' experiences, perceptions, and learning processes within AI-assisted science learning environments. The design facilitated the identification of emerging patterns that explain how Artificial Intelligence supports creativity, innovation, and scientific inquiry (Chavez, 2025).

Participants and Sampling

The study involved twenty-five (25) purposively selected undergraduate students enrolled in science-related programs from selected higher education institutions. Purposive sampling was employed to recruit participants who possessed relevant experiences with Artificial Intelligence-assisted science learning. Participants met the following inclusion criteria: (1) currently enrolled in a science-related program; (2) have used Artificial Intelligence tools (e.g., ChatGPT, Microsoft Copilot, Google Gemini, or similar AI applications) to support science learning; (3) have participated in science-related learning activities involving inquiry, experimentation, or problem-solving; (4) were willing to participate in the study; and (5) could effectively communicate their learning experiences during the interview.

Research Instrument

Data were collected using a researcher-developed semi-structured interview guide consisting of three open-ended questions aligned with the study's objective. The interview guide explored participants' experiences with Artificial Intelligence-assisted science learning, its influence on inventive thinking, and its contribution to creativity, problem-solving, and innovation in science education. Follow-up probing questions were used when necessary to clarify responses and obtain richer descriptions of participants' experiences. Prior to data collection, the interview guide underwent expert validation to ensure its clarity, relevance, and alignment with the research objective.

Table 1. Interview guide used in gathering the narrative data

Objective	Interview Questions
To explore how Artificial Intelligence-assisted science learning influences the development of inventive thinking among higher education students.	How has Artificial Intelligence-assisted learning influenced the way you learn science and develop inventive thinking? What learning experiences with Artificial Intelligence have helped you become more creative and innovative when solving science-related problems? How does Artificial Intelligence-assisted science learning influence your ability to generate ideas, solve scientific problems, and develop innovative solutions?

Data Gathering Procedure

After obtaining the necessary institutional permission, participants were recruited through purposive sampling. The purpose of the study was explained, and written informed consent was secured before the interviews were conducted. Individual semi-structured interviews were conducted either face-to-face or through online communication platforms, depending on participants' availability. Each interview lasted approximately 30 to 45 minutes and was audio-recorded with participants' permission. The recordings were subsequently transcribed verbatim to facilitate data analysis.

Data Analysis

The interview transcripts were analyzed using Reflexive Thematic Analysis following the approach of Braun and Clarke (2019). The researcher repeatedly reviewed the transcripts to become familiar with the data before generating initial codes. Related codes were then grouped into categories and refined into broader themes that

reflected participants' shared experiences of Artificial Intelligence-assisted science learning and the development of inventive thinking. Throughout the analysis, reflexivity was maintained to enhance the credibility, trustworthiness, and interpretive rigor of the findings.

Results

Objective. To explore how Artificial Intelligence-assisted science learning influences the development of inventive thinking among higher education students.

Interview Question 1. How has Artificial Intelligence-assisted learning influenced the way you learn science and develop inventive thinking?

Theme 1. Conceptual Understanding

13 participants described Artificial Intelligence as a valuable learning companion that helped them understand complex scientific concepts more effectively. AI-assisted learning enabled them to obtain simplified explanations, alternative examples, and immediate responses to scientific questions that were difficult to understand during classroom instruction. Participants explained that AI helped them connect theoretical concepts with practical scientific applications, allowing them to develop a deeper understanding of science lessons while encouraging them to explore topics beyond classroom discussions.

"Whenever I don't understand a science lesson, I ask AI to explain it differently, and it becomes easier to understand."

"AI gives examples that help me connect scientific concepts to real-life situations."

Theme 2. Learning Support

12 participants also viewed Artificial Intelligence as a learning support tool that provided immediate guidance during science-related activities. Rather than replacing classroom instruction, AI assisted them in organizing ideas, reviewing scientific information, and clarifying misconceptions while completing laboratory activities, research tasks, and assignments. Participants emphasized that AI encouraged them to become more independent learners by allowing them to explore scientific concepts at their own pace.

"AI helps me whenever I get confused because I can immediately ask questions while studying."

"It feels like having a tutor available anytime I need help with science."

Interview Question 2. What learning experiences with Artificial Intelligence have helped you become more creative and innovative when solving science-related problems?

Theme 1. Creative Exploration

15 participants shared that Artificial Intelligence encouraged them to explore multiple ideas and alternative approaches when solving scientific problems. AI-generated suggestions exposed them to different perspectives, allowing them to expand their thinking beyond conventional solutions. Several participants explained that interacting with AI motivated them to experiment with new ideas and improve existing concepts before implementing them in science-related activities.

"AI gives different suggestions that help me think of more creative solutions."

"Instead of giving only one answer, AI makes me consider different possibilities."

Theme 2. Scientific Problem-Solving

10 participants explained that Artificial Intelligence supported their scientific problem-solving skills by helping them analyze information, organize scientific procedures, and evaluate possible solutions. AI-assisted learning enabled them to approach scientific tasks more systematically while encouraging logical reasoning during experiments, investigations, and research activities.

"AI helps me organize my ideas before conducting experiments."

"It helps me understand different ways of solving scientific problems instead of following only one method."

Interview Question 3. How does Artificial Intelligence-assisted science learning influence your ability to generate ideas, solve scientific problems, and develop innovative solutions?

Theme 1. Idea Generation

11 participants reported that Artificial Intelligence stimulates idea generation by providing new perspectives, examples, and recommendations during science learning. They explained that AI-assisted learning broadens their thinking and encourages them to refine their own ideas rather than simply copying generated responses. Participants viewed AI as a source of inspiration that supports innovation while maintaining personal creativity.

"AI gives me ideas that I can improve and develop into my own project."
"It helps me brainstorm different possibilities before deciding on the best solution."

Theme 2. Innovation Skills

14 participants believed that Artificial Intelligence contributes to the development of innovation skills by encouraging experimentation, continuous improvement, and evidence-based decision-making. They explained that AI-assisted learning allows them to evaluate different scientific approaches, refine project ideas, and improve the quality of their outputs through repeated analysis and revision.

"AI helps me improve my projects because it suggests ways to make them better."
"It encourages me to keep improving my ideas until I find the best solution."

Discussion

Conceptual Understanding. The findings suggest that Artificial Intelligence-assisted learning has transformed science education by making complex scientific concepts more accessible and comprehensible to learners. Rather than functioning solely as a source of information, AI serves as an interactive learning partner that supports knowledge construction through personalized explanations and adaptive feedback. This reflects a shift from passive content acquisition toward learner-centered engagement, where students actively construct scientific understanding through continuous interaction with digital technologies.

These findings are consistent with Chen and Tsai (2021), who argued that student-centered learning environments encourage learners to actively construct knowledge through meaningful experiences rather than passively receiving information. Similarly, Shehata et al. (2024) emphasized that educational technologies enhance conceptual understanding by promoting interactive learning and collaborative knowledge construction. UNESCO (2023) likewise recognized generative Artificial Intelligence as a valuable educational resource capable of improving conceptual learning when used responsibly. The present study extends these perspectives by demonstrating that AI-assisted science learning enables students to better interpret scientific concepts while supporting the development of inventive thinking.

Learning Support. Artificial Intelligence appears to function as an accessible learning support system that complements formal classroom instruction by providing immediate academic assistance whenever learners encounter difficulties. Instead of replacing teachers, AI expands learning opportunities beyond classroom boundaries by enabling students to independently review concepts, clarify misconceptions, and explore scientific ideas at their own pace. Such flexibility strengthens learner autonomy while encouraging continuous engagement with science learning.

This observation supports Ahmed (2025), who emphasized that digital innovation enhances instructional effectiveness by creating more flexible and learner-responsive educational environments. Likewise, Dwivedi et al. (2023) explained that generative AI supports education by facilitating personalized learning experiences and providing immediate access to relevant knowledge. From the perspective of Constructivist Learning Theory, AI-assisted learning provides an environment in which learners actively construct understanding through continuous interaction, reflection, and exploration rather than relying exclusively on teacher-directed instruction (Chen & Tsai, 2021).

Creative Exploration. The findings indicate that Artificial Intelligence contributes to creative exploration by exposing students to multiple perspectives and alternative approaches when addressing scientific problems. Rather than limiting creativity, AI appears to broaden learners' thinking by encouraging them to evaluate different possibilities before selecting or refining their own ideas. This suggests that AI can facilitate divergent thinking, an essential component of inventive thinking and scientific innovation.

These findings agree with Garner et al. (2021), who emphasized that invention education encourages learners to explore ideas, develop creative confidence, and engage in authentic problem-solving experiences. Similarly, Patel et al. (2024) reported that innovation-oriented learning environments strengthen learners' confidence and creativity through opportunities to generate and refine original ideas. The present study contributes to this literature by illustrating how Artificial Intelligence can stimulate idea exploration without diminishing learners' creative ownership of scientific solutions.

Scientific Problem-Solving. Artificial Intelligence-assisted learning also appears to strengthen students' scientific problem-solving by supporting systematic reasoning and evidence-based decision-making. Access to AI-generated explanations and alternative procedures enables learners to organize information more effectively, compare different strategies, and make informed decisions when conducting scientific investigations. Such experiences contribute to the development of analytical thinking required for addressing increasingly complex scientific challenges.

This finding supports Mat and Jamaludin (2024), who emphasized that higher-order cognitive processes, including reasoning and problem-solving, are fundamental to effective science learning. Likewise, Samodra et al. (2026) argued that inquiry-based science education should cultivate critical thinking and adaptive problem-solving rather than simple knowledge acquisition. The present findings suggest that Artificial Intelligence strengthens these competencies by functioning as a cognitive support tool that facilitates reflective scientific inquiry.

Idea Generation. The findings suggest that Artificial Intelligence enhances students' capacity for idea generation by providing diverse perspectives that stimulate innovation and scientific creativity. Rather than producing finished solutions, AI appears to encourage learners to expand, modify, and improve their own ideas through iterative exploration. This demonstrates that AI can function as a catalyst for creative thinking while preserving learners' active role in the innovation process.

These observations are consistent with Ng et al. (2026), who described inventive thinking as a combination of creativity, curiosity, and higher-order cognition that enables learners to generate innovative solutions to unfamiliar problems. Similarly, Ou et al. (2024) emphasized that innovative learning environments promote experimentation and knowledge creation by encouraging learners to explore multiple possibilities. The present study extends these perspectives by identifying Artificial Intelligence as an emerging educational resource that supports idea generation within science learning.

Innovation Skills. Perhaps the most significant contribution of the study is the recognition that Artificial Intelligence-assisted science learning supports the continuous refinement of innovative solutions rather than merely improving academic performance. Students viewed innovation as an iterative process of evaluating, revising, and improving ideas through continuous feedback and experimentation. This reflects an important shift in science education toward learning environments that prioritize innovation, adaptability, and lifelong learning.

This finding aligns with Fuad et al. (2022), who concluded that innovative cultures develop when learners are encouraged to experiment, collaborate, and continuously improve their ideas. Likewise, OECD (2023) emphasized that future-ready learners require innovation competencies that extend beyond scientific knowledge to include creativity, adaptability, and problem-solving. Guided by Social Constructivism, these findings suggest that Artificial Intelligence serves as a collaborative learning resource that supports the co-construction of knowledge while strengthening inventive thinking through meaningful interaction and continuous reflection (Shehata et al., 2024).

Overall, the study demonstrates that Artificial Intelligence-assisted science learning functions as an enabling educational resource that supports conceptual understanding, learner autonomy, creative exploration, scientific problem-solving, idea generation, and innovation skills. Rather than replacing human creativity, AI complements student-centered science education by creating learning experiences that encourage inquiry, experimentation, and the development of inventive thinking required in contemporary scientific and technological environments.

Conclusion

This study explored how Artificial Intelligence-assisted science learning influences the development of inventive thinking among higher education students. The findings indicate that AI serves as a valuable educational resource by enhancing students' conceptual understanding, supporting independent learning, encouraging creative exploration, and strengthening scientific problem-solving. Through AI-assisted learning, students are better equipped to generate ideas, evaluate alternative solutions, and engage in inquiry-based learning experiences that promote creativity and innovation in science education. Rather than replacing traditional instruction, AI complements learner-centered pedagogies by providing timely guidance and opportunities for deeper scientific engagement.

The study further demonstrates that the development of inventive thinking depends not only on the availability of Artificial Intelligence but also on how it is meaningfully integrated into science instruction. AI-assisted learning

is most effective when combined with inquiry-based teaching, collaborative learning, and authentic scientific experiences that encourage students to think critically and innovate responsibly. These findings highlight the importance of equipping educators with the competencies to integrate AI into science education while fostering students' creativity, scientific reasoning, and innovation skills necessary for addressing real-world challenges in an increasingly technology-driven society...

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