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Article

Artificial Intelligence and Instructional Strategies in Science Education: Cultivating Industry-Relevant Innovative Competencies among Diverse Learners

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Abstract: Higher education institutions are increasingly challenged to prepare graduates who can thrive in technology-driven industries characterized by rapid innovation, evolving workforce expectations, and continuous technological change. Responding to these demands requires science education to move beyond disciplinary knowledge toward cultivating the higher-order competencies necessary for innovation and professional adaptability. This study examined how science education in the Zamboanga Peninsula, an emerging region in the Philippines, contributes to the development of industry-relevant innovative competencies through the integration of artificial intelligence (AI) and instructional practices. Using a qualitative design, the study involved in-depth interviews with 20 college students enrolled in science-related programs. The interview data were interpreted through reflexive thematic analysis to examine how learners perceived the role of AI and classroom instruction in shaping their learning experiences and professional competencies. The findings indicate that innovative competencies emerge through the dynamic interaction among AI technologies, instructors, peers, and structured learning environments. Participants described meaningful improvements in creativity, analytical problem-solving, decision-making, and learner autonomy as they engaged with AI-generated guidance alongside teacher-facilitated instruction. Rather than serving merely as instructional aids, AI applications and educators jointly functioned as cognitive and procedural scaffolds by providing structured explanations, alternative perspectives, timely feedback, and opportunities for reflective learning. These interactions supported the gradual internalization of systematic reasoning and strengthened students' capacity for independent problem solving. Furthermore, the narratives suggest that AI-assisted learning and teacher-mediated instruction operate as complementary social learning processes in which observation, modeling, feedback, and sustained cognitive engagement collectively foster industry-relevant innovation competencies. These findings underscore the value of intentionally integrating AI within science education, not simply as a technological resource but as part of pedagogical practices that promote higher-order thinking, innovation, and workforce readiness among diverse learners.
Keywords: artificial intelligence, instructional strategies, innovation, science education, social learning theory,

1. Introduction

The accelerating pace of technological innovation has transformed the expectations placed on higher education, requiring institutions to prepare graduates who can navigate increasingly complex and technology-driven professional environments. As artificial intelligence (AI), automation, and other digital technologies continue to redefine the nature of work, employers have placed greater value on graduates who demonstrate adaptability, innovation, and the capacity to apply knowledge in dynamic settings rather than relying solely on disciplinary expertise (Koch et al., 2025; Naseer et al., 2025). Consequently, developing industry-responsive competencies has become a critical objective of contemporary science education.

Despite these evolving workforce expectations, many higher education programs have been slow to redesign their curricula and instructional practices in ways that meaningfully reflect emerging industry requirements (Naseer et al., 2025). This disconnect raises important questions about how educational institutions are preparing students for an increasingly technology-oriented economy. To address this concern, the present study examined science education in the Zamboanga Peninsula, Philippines, a region undergoing sustained economic and technological growth. With expanding sectors in education, agriculture, commerce, and innovation, the region provides an appropriate setting for exploring how science education cultivates competencies that correspond to the changing demands of modern industries (Moreno & Sulasula, 2024).

Social learning theory conceptualizes learning as an active process shaped by the reciprocal interaction of individuals, their behaviors, and the environments in which they participate (Mukhalalati et al., 2022). Rather than viewing knowledge acquisition as the product of direct instruction alone, the theory explains that learners construct understanding by observing models, interpreting the consequences of others' actions, receiving feedback, and regulating their own thinking and behavior (Rumjaun & Narod, 2025; Krishna et al., 2024). Through these interconnected processes, learners progressively develop new competencies, refine existing skills, and strengthen their capacity for independent learning.

Within science education, the principles of social learning are reflected in instructional practices that encourage students to engage actively with scientific concepts instead of passively receiving information. Pedagogical approaches such as modeling, scaffolding, guided inquiry, and self-monitoring enable learners to navigate complex scientific ideas while developing analytical reasoning and problem-solving abilities (Azzaroiha et al., 2025). These learning experiences are further enriched through experimentation, collaboration, and reflective practice, where teachers play a pivotal role in demonstrating scientific procedures, facilitating conceptual understanding, and providing feedback that supports students' cognitive growth (Feri et al., 2022; Ferniawan et al., 2025).

From a social learning perspective, meaningful learning emerges through the continuous interplay of personal attributes, observable behaviors, and environmental influences. Central constructs, including modeling, self-efficacy, outcome expectations, and self-regulation, explain how learners transform observation into sustained competence and independent performance (Bandura, 1999; Mukhalalati et al., 2022). This theoretical perspective provides a relevant foundation for understanding how interactions with instructors, peers, and AI-supported learning environments collectively contribute to the development of scientific knowledge, innovation-related competencies, and industry-relevant skills.

The increasing complexity of technology-driven industries has redefined the competencies expected of higher education graduates, extending beyond disciplinary knowledge to include innovation, critical thinking, adaptability, and lifelong learning (Koch et al., 2025; Naseer et al., 2025). These changing workforce expectations have prompted greater attention to pedagogical approaches that cultivate such competencies within science education. Among these, social learning offers a valuable framework by emphasizing collaborative learning, observation, guided practice, and reflective engagement through instructional strategies such as scaffolding, modeling, and self-monitoring (Bhardwaj et al., 2025). Collectively, these practices create learning environments that promote inquiry, strengthen problem-solving abilities, and support the development of innovation-oriented competencies.

Despite the recognized value of social learning in science education, its application within AI-supported learning environments remains insufficiently understood. In particular, limited research has examined how social learning processes operate when students interact simultaneously with instructors, peers, and artificial intelligence in developing competencies that align with the innovation demands of contemporary industries. This gap highlights the need to investigate how AI-enhanced science education can extend traditional social learning processes to foster industry-relevant innovative capabilities.

2. Literature Review

Rapid technological advancement has transformed the nature of work, creating industries that are increasingly characterized by digitalization, continuous innovation, and evolving workplace expectations. Consequently, employers now seek professionals who possess not only technical expertise but also the capacity to think critically, solve complex problems, and adapt to emerging technologies throughout their careers (Koch et al., 2025; Naseer et al., 2025). These developments have intensified the responsibility of higher education institutions to design learning experiences that cultivate innovation-oriented competencies and prepare students for an increasingly dynamic workforce.

Social Learning Theory, later expanded as Social Cognitive Theory by Albert Bandura, provides a relevant theoretical lens for understanding how such competencies develop within educational settings. Rather than viewing learning as the product of direct instruction alone, the theory explains that individuals acquire knowledge, skills, and behaviors through continuous interaction with their social environment. Learning is shaped as students observe competent models, interpret the consequences of their actions, imitate effective practices, and refine their own performance through reflection and feedback (Bandura & Walters, 1977; Bandura, 2012; Feri et al., 2022). This process of observational learning positions social interaction as a central mechanism through which learners gradually internalize new ways of thinking and acting (Mukhalalati et al., 2022).

Viewed from this perspective, science education extends beyond the transmission of scientific knowledge to the creation of learning environments where students develop professional competencies through guided participation and collaborative engagement. Interactions with instructors, peers, and increasingly with AI-powered learning technologies provide opportunities for modeling, feedback, and cognitive support that strengthen higher-order thinking and adaptive problem-solving. Accordingly, the present study applies Social Learning Theory to examine how these interconnected learning experiences contribute to the development of industry-relevant innovative competencies among science students.

Bandura's refinement of Social Learning Theory into **Social Cognitive Theory** broadened the explanation of learning by recognizing that behavior is shaped not only through observation but also through cognitive and motivational processes. The theory proposes that learning emerges from the reciprocal interaction among personal characteristics, behavioral responses, and environmental influences, with constructs such as self-efficacy, self-regulation, outcome expectations, and modeling explaining how individuals acquire and sustain new competencies (Bandura, 1999; Mukhalalati et al., 2022). Rather than portraying learners as passive recipients of knowledge, Social Cognitive Theory views them as active participants who interpret experiences, regulate their own learning, and continuously refine their performance through social interaction.

This theoretical perspective is particularly relevant to contemporary science education, where preparing students for rapidly evolving industries requires instructional approaches that cultivate innovation, critical thinking, and adaptive problem-solving. Student-centered pedagogies grounded in inquiry, collaboration, and reflective learning encourage learners to investigate authentic problems, construct knowledge through exploration, and develop creative solutions instead of relying solely on the memorization of scientific concepts (Bhardwaj et al., 2025; Nurhidayah & Wahyudi, 2026). Within these learning environments, interactions with instructors and peers provide opportunities for observation, guided practice, and constructive feedback, enabling students to strengthen their reasoning processes and make more informed decisions as they engage in scientific inquiry (Mukhalalati et al., 2022).

The effectiveness of these learning environments is further reinforced through instructional strategies such as scaffolding, modeling, and self-monitoring. Rather than functioning as isolated teaching techniques, these strategies work collectively to support learners as they gradually assume greater responsibility for their own learning. By combining guided instruction with opportunities for reflection and independent application, students develop stronger metacognitive awareness, greater autonomy, and the capacity to transfer scientific knowledge to unfamiliar and complex situations (Bhardwaj et al., 2025).

Despite the growing relevance of Social Cognitive Theory to science education, limited attention has been given to how its core principles operate within AI-supported learning environments. Existing scholarship has yet to fully explain how observational learning, collaborative engagement, and guided instructional support are transformed when artificial intelligence becomes part of the learning process. Addressing this gap, the present study examines how interactions among students, instructors, peers, and AI technologies collectively contribute to the development of innovation-related competencies and industry-relevant capabilities in science education.

Objectives

This study explored how science education in the Zamboanga Peninsula, Philippines fosters the development of industry-relevant innovative competencies among university students through the integration of artificial intelligence (AI) and instructional strategies. Specifically, it sought to:

1. Examine how AI-integrated science education contributes to the development of industry-relevant innovative competencies among diverse university learners.
2. Explore how instructional strategies facilitate the enhancement of students' creativity, critical thinking, problem-solving, adaptability, and other competencies aligned with contemporary industry demands.

3. Methodology

Research Design

A qualitative exploratory approach was adopted to gain an in-depth understanding of how university graduates perceived the role of science education in cultivating industry-relevant innovative competencies through the integration of artificial intelligence (AI) and instructional practices. Rather than measuring predetermined outcomes, the study sought to capture participants' accounts of how AI-supported learning experiences, classroom interactions, and pedagogical strategies shaped their creativity, critical thinking, adaptability, collaboration, and problem-solving abilities. These narratives provided a richer understanding of the learning processes that contribute to the development of competencies valued in contemporary industries.

The exploratory design was selected because the phenomenon remains insufficiently examined, particularly within AI-enhanced science education. This approach enabled the researchers to investigate participants' perspectives in depth, uncover patterns across their experiences, and generate context-specific insights that may inform the refinement of science instruction and the design of educational practices responsive to evolving industry demands (Chavez et al., 2024).

Research Setting

The research was undertaken in the Zamboanga Peninsula, Philippines, with participants drawn from universities offering science-related degree programs. The region was intentionally selected because of its continuing socioeconomic and technological transformation, which has positioned it as an emerging center for education, agriculture, commerce, and innovation within the country (Moreno & Sulasula, 2024). Given these developments, the Zamboanga Peninsula provides a relevant context for examining how science education, supported by AI and instructional practices, contributes to the development of innovation-oriented competencies that correspond with the evolving needs of contemporary industries.

Participants of the Study

Participants were recruited through purposive sampling to ensure the inclusion of individuals with firsthand experience relevant to the phenomenon under investigation. Consistent with the objectives of the study, 20 university students were selected based on predetermined inclusion criteria. Eligible participants were those who were enrolled during the 2025–2026 academic year, pursuing science-related programs, and regularly engaged in AI-supported learning through generative AI applications for academic purposes. They were also required to have experienced technology-enhanced or innovation-oriented instructional practices, demonstrate the ability to articulate their learning experiences, and voluntarily agree to participate in the study by providing informed and relevant insights. Selecting participants with these characteristics ensured that the data were derived from individuals who could meaningfully describe how AI-integrated science education and instructional practices contributed to the development of industry-relevant innovative competencies. The use of purposive sampling is appropriate in qualitative research because it facilitates the selection of information-rich participants who can provide detailed and contextually relevant accounts of the phenomenon being examined (Nyimbili & Nyimbili, 2024).

Research Instrument

Data were collected through semi-structured interviews, which served as the primary instrument for eliciting participants' experiences and perspectives. An interview guide provided a consistent framework for the discussion while allowing sufficient flexibility to pursue emerging topics and explore issues raised by the participants in greater depth. Throughout the interviews, probing and follow-up questions were employed to clarify responses, encourage elaboration, and capture nuanced accounts of participants' experiences. This flexible approach facilitated the collection of rich and contextually grounded data, making it well suited for addressing the objectives of the study (Chavez et al., 2026). The semi-structured interview guide used in the study is presented in Table 1.

Objectives	Interview Questions
To examine how AI-integrated science education contributes to the development of industry-relevant innovative competencies among diverse university learner	1. Describe how your experiences with AI-integrated learning in your science courses have influenced the way you approach academic tasks and solve problems. 2. Can you share a situation in which using AI helped you generate new ideas, make better decisions, or approach a scientific problem differently? What did you learn from that experience? 3. In what ways has learning with AI strengthened the knowledge, skills, or competencies that you believe are important for future professional or industry-related work?
To explore how instructional strategies facilitate the enhancement of students' creativity, critical thinking, problem-solving, adaptability, and other competencies aligned with contemporary industry demands.	1. Which teaching strategies used in your science classes have had the greatest influence on your creativity, critical thinking, or adaptability? Please describe your experience. 2. Tell me about a classroom activity or learning experience that significantly improved your ability to solve problems, collaborate with others, or apply scientific concepts to real-life situations. 3. Looking back on your learning experiences, how have your instructors' teaching approaches prepared you to meet the expectations of today's technology-driven and innovation-oriented workplaces?

Data Gathering Procedure

Data collection followed a systematic procedure guided by established ethical principles to ensure the credibility and trustworthiness of the study. Eligible participants were invited individually and provided with detailed information regarding the purpose of the research, the nature of their participation, and their rights as research participants. Prior to the interviews, informed consent was obtained, emphasizing that participation was entirely voluntary and that all information shared would be treated with strict confidentiality and anonymity.

To accommodate participants from different locations within the Zamboanga Peninsula and maximize accessibility, interviews were conducted remotely using telephone calls or Facebook Messenger, based on each participant's preferred communication platform. This flexible approach enabled the researchers to engage participants despite geographical limitations while maintaining the depth and quality of the interview process. Each interview lasted approximately 45 to 60 minutes, allowing ample opportunity for participants to recount their experiences and elaborate on issues relevant to the study.

With participants' permission, all interviews were audio-recorded to ensure an accurate and complete account of the discussions during transcription and analysis. The researchers also maintained field notes throughout each interview to capture contextual observations, nonverbal cues that could be inferred from participants' interactions, emerging reflections, and other details that enriched the interpretation of the qualitative data.

Data Analysis

The study generated qualitative data from the narratives shared by university students regarding their experiences with AI-integrated science education and instructional practices. These narratives were analyzed using reflexive thematic analysis, an approach that emphasizes the active role of the researcher in interpreting patterns of meaning while remaining responsive to the context in which participants' experiences are situated (Chavez et al., 2026).

The analytical process commenced with the verbatim transcription of all interview recordings to preserve the authenticity and richness of participants' accounts. The transcripts were read repeatedly to facilitate familiarization with the data, allowing the researchers to identify preliminary insights and develop a deeper understanding of participants' experiences before formal coding began.

Subsequently, meaningful segments of text were systematically coded and compared across transcripts to identify recurring ideas and shared patterns. Related codes were then consolidated into conceptual categories, which underwent continuous review, refinement, and interpretation until they evolved into coherent themes that reflected the underlying meanings embedded within the participants' narratives. Rather than merely describing common responses, the analysis sought to explain how participants experienced AI-assisted learning and instructional practices within the broader context of science education.

To enhance the trustworthiness of the findings, reflexivity was maintained throughout the analytic process. The researchers continuously examined their assumptions, interpretations, and potential biases while revisiting the data to ensure that the resulting themes were grounded in participants' narratives and accurately represented the complexity of their experiences.

4. Results

Objective 1. *To examine how AI-integrated science education contributes to the development of industry-relevant innovative competencies among diverse university learners.*

Question 1. *Describe how your experiences with AI-integrated learning in your science courses have influenced the way you approach academic tasks and solve problems.*

Theme 1: AI-Facilitated Creative Ideation

Participants consistently viewed AI as a valuable tool for generating ideas and expanding their thinking during science learning. They explained that AI facilitated brainstorming, exposed them to alternative perspectives, and helped refine initial concepts into more creative and well-developed outputs. Beyond providing information, AI supported students in exploring different approaches to assignments and experiments, enabling them to produce more innovative solutions and improve the quality of their academic work.

> *"Using AI in my science classes has made it easier for me to generate new ideas."*
>
> *"AI gives me more options when completing assignments and designing experiments."*
>
> *"Before finalizing my work, I use AI to brainstorm and improve my ideas."*
>
> *"AI has helped me become more creative and produce better-quality outputs in my science subjects."*

Theme 2: AI-Supported Analytical Problem Solving

Participants perceived AI as an effective learning support that strengthened their analytical and problem-solving skills in science. They shared that AI simplified complex concepts through clear explanations, step-by-step guidance, and organized information, enabling them to understand difficult topics more effectively. By providing structured assistance, AI helped students solve scientific problems more systematically and produce more accurate academic outputs.

> *"I understand difficult science concepts better when AI explains them step by step."*
>
> *"AI guides me through the correct process whenever I struggle with complicated science problems."*
>
> *"The step-by-step support provided by AI helps me solve science problems more accurately and systematically."*
>
> *"I frequently use ChatGPT to better understand difficult science concepts, organize my ideas, and receive clear explanations and guided solutions for my assignments.*

Theme 3: Fostering Learner Autonomy through AI

A recurring pattern across the interviews was the growing independence students demonstrated in managing their own learning. AI expanded opportunities to investigate scientific concepts beyond classroom discussions, allowing learners to regulate their pace, select strategies that suited different academic tasks, and seek clarification without waiting for teacher intervention. This greater sense of ownership over the learning process reflects the development of adaptive and self-directed competencies expected in contemporary learning and professional environments.

> *"AI allows me to explore science topics that are not covered in class, making me more independent as a learner."*
>
> *"I can adjust my pace depending on how challenging the lesson is."*
>
> *"Instead of immediately asking my teacher, I first use AI to understand the topic on my own."*

Question 2. *Can you share a situation in which using AI helped you generate new ideas, make better decisions, or approach a scientific problem differently? What did you learn from that experience?*

Theme 1: Strengthened Analytical Problem-Solving

Analytical reasoning emerged as one of the most evident competencies developed through AI-integrated science learning. Students recognized AI as a resource that clarified complex concepts, organized scientific information into manageable steps, and supported more systematic approaches to solving academic problems. As a result, they became more confident in interpreting data, evaluating possible solutions, and completing science-related tasks with greater accuracy and efficiency.

> "AI made it easier for me to break down difficult science problems into simpler and more manageable parts."
>
> "Using AI helps me better understand complex concepts and determine the most appropriate solutions."
>
> "AI has taught me to approach problems more logically and systematically."
>
> "My responses to science activities have become more organized and efficient because of the guidance AI provides."

Theme 2: Bridging Classroom Learning and Industry Practice

The interviews revealed that AI made science learning more relevant to real-world applications by connecting theoretical concepts with practical situations. Rather than limiting learning to textbook discussions, AI exposed students to authentic scenarios, guided applications, and task-oriented experiences that reflected workplace expectations. Such experiences allowed learners to appreciate the practical value of scientific knowledge while strengthening competencies considered essential in professional settings.

> *"AI helped me understand how scientific knowledge can be applied to practical situations that I may encounter in the workplace."*
>
> *"I use Gemini to improve my presentation materials, making them clearer and more professional."*
>
> *"Working with AI has made me feel more prepared for tasks similar to those performed in industry."*
>
> *"ChatGPT helped me understand how scientific* concepts can be applied in real-world situations."

Theme 3: More Deliberate Decision-Making

An emerging pattern across the interviews was students' growing ability to make informed academic decisions. Rather than arriving at immediate conclusions, learners used AI to compare alternatives, clarify uncertainties, and reflect on possible courses of action before completing their tasks. This process encouraged a more thoughtful and strategic approach to learning, allowing students to adapt their decisions to different academic situations and solve problems with greater confidence.

> *"Whenever I feel uncertain about my thesis, I consult ChatGPT to organize my thoughts before making a decision."*
>
> *"AI helps me evaluate which ideas are more practical and effective for the task."*
>
> *"When I struggle with concepts in my thesis, ChatGPT helps me clarify my thinking and choose the best approach."*
>
> *"Comparing different solutions with AI has made me more careful and confident in making decisions."*

Question 3. *In what ways has learning with AI strengthened the knowledge, skills, or competencies that you believe are important for future professional or industry-related work?*

Theme 1: Scaffolding Complex Scientific Learning

The findings indicate that AI served as an instructional scaffold that reduced the difficulty of complex scientific tasks. Students relied on AI to clarify laboratory procedures, explain challenging concepts, and organize unfamiliar information into manageable parts. This support enabled learners to approach coding activities, scientific analyses, and laboratory work with greater confidence while developing a more structured and analytical way of thinking.

> "I rely on AI during complex laboratory activities because it helps me understand the procedures and interpret the results more accurately."

> "AI makes difficult science topics easier to understand by presenting explanations in a simpler and more organized way."

> "AI has made my approach to problem-solving more systematic by guiding me through each stage of the analysis."

> "Whenever I struggle with coding or challenging science concepts, I use AI to guide me through the process until I understand it better."

Theme 2: Refining Academic Work through AI Feedback

The interviews revealed that AI played an important role in strengthening the quality of students' academic work by providing timely feedback and alternative perspectives. Rather than accepting their initial responses, learners used AI to identify errors, verify interpretations, compare possible explanations, and refine their outputs before submission. This process encouraged critical reflection and more informed academic decision-making across science-related tasks.

> *"Google Colab's coding suggestions helped me correct errors and stay on track while completing my Python projects."*

> *"ChatGPT helped me interpret microscope images more accurately, making it easier to understand my observations and draw appropriate conclusions."*

> *"AI tools helped me identify mistakes in my code, allowing me to evaluate and improve my work before finalizing it."*

> *"AI often suggested alternative explanations for my science outputs, giving me the opportunity to compare ideas and determine the most appropriate interpretation."*

Theme 3: Considering Multiple Perspectives

The narratives suggest that AI encouraged students to move beyond their initial ideas by exposing them to alternative explanations and problem-solving approaches. Rather than relying on a single solution, learners compared different options, evaluated their strengths, and selected the most appropriate response for a given task. This process promoted greater cognitive flexibility and encouraged a more reflective approach to academic decision-making.

> *"AI shows me different ways of completing a task, so I do not rely on the first solution that comes to mind."*

> *"It presents different perspectives that allow me to compare approaches and determine which one is most effective."*

> *"I use AI as a reference to explore alternative ideas and strengthen my critical thinking."*

> *"While working on my thesis, I initially followed the method used in a published study. After consulting AI, I discovered a more suitable approach that better fit my research."*

Objective 2. *To explore how instructional strategies facilitate the enhancement of students' creativity, critical thinking, problem-solving, adaptability, and other competencies aligned with contemporary industry demands.*

Question 1. *Which teaching strategies used in your science classes have had the greatest influence on your creativity, critical thinking, or adaptability?*

Theme 1: Nurturing Creative Thinking

Creative thinking emerged as a recurring outcome of the instructional approaches employed in science classes. Learning activities that emphasized inquiry, discussion, and hands-on exploration encouraged students to question ideas, examine concepts from different perspectives, and develop original solutions to scientific problems. These experiences fostered curiosity and allowed learners to connect scientific knowledge with authentic situations in more meaningful and innovative ways. “When our science instructor uses activities that require independent thinking, I become more encouraged to find different ways to understand and answer a scientific problem.”

> *"Activities that require independent thinking encourage me to explore different ways of understanding and solving scientific problems."*

> *"Class discussions and inquiry-based activities allow me to develop and express my own ideas."*

> *"Hands-on activities encourage me to examine concepts from different perspectives and develop more creative solutions."*

> *"My instructor's teaching strategies help me connect scientific concepts to real-life situations, which broadens my way of thinking."*

Theme 2: Building Confidence in Problem Solving

Students associated their growth in problem-solving with instructional activities that required them to apply scientific concepts to authentic situations. Problem-based tasks, collaborative discussions, and analytical exercises challenged learners to examine issues critically, weigh alternative solutions, and justify their decisions. These classroom experiences not only strengthened their reasoning skills but also increased their confidence in addressing complex academic and workplace-related challenges.

> *"Real-life learning activities give me opportunities to analyze problems and identify practical solutions."*

> *"Group discussions expose me to different viewpoints, allowing us to combine ideas and arrive at better solutions."*

> *"Problem-based activities encourage me to persist and look for solutions instead of giving up when lessons become difficult."*

> *"Application-based tasks have prepared me to handle complex problems that I may encounter in my future career."*

Theme 3: Adapting to Diverse Learning Contexts

Students recognized that varied instructional approaches encouraged them to become more flexible in responding to different learning situations. Exposure to diverse teaching methods, classroom activities, and educational technologies challenged learners to adjust their learning strategies, embrace unfamiliar experiences, and remain resilient when faced with new academic demands. Such experiences cultivated adaptability, a competency they viewed as valuable for both higher education and future professional practice.

> *"The different teaching approaches used by my science instructor have taught me to adjust my learning strategies depending on the lesson."*

> *"Using different technologies and learning tools has made me more flexible and quicker to adapt to new ways of learning."*

> *"Whenever classroom activities or teaching approaches change, I learn to stay resilient and adjust instead of becoming overwhelmed."*

Question 2. *Tell me about a classroom activity or learning experience that significantly improved your ability to solve problems, collaborate with others, or apply scientific concepts to real-life situations.*

Theme 1: Learning through Systematic Inquiry

The findings suggest that structured classroom activities cultivated a more disciplined approach to scientific reasoning. Case studies, authentic problem scenarios, and guided learning tasks encouraged students to examine issues methodically, justify their decisions with evidence, and consider multiple perspectives before arriving at conclusions.

Rather than focusing on immediate answers, these learning experiences promoted careful analysis, collaborative reasoning, and thoughtful decision-making.

> *"Case studies and problem-solving activities encourage us to analyze each part of the problem instead of looking for an immediate answer."*

> *"Working on real-life cases with my classmates teaches me to examine problems systematically while considering different ideas before deciding on the best solution."*

Theme 2: Learning through Collaborative Engagement

Collaboration emerged as a key element of students' learning experiences in science classrooms. Group activities and peer discussions created opportunities for learners to exchange ideas, negotiate different viewpoints, and work collectively toward shared solutions. These interactions strengthened not only their communication and teamwork skills but also their ability to appreciate diverse perspectives when addressing academic challenges.

> *"Group activities have taught me to coordinate with my classmates, discuss different ideas, and reach a common solution before completing our tasks."*

> *"Problem-solving activities become more meaningful when ideas are shared because discussing different perspectives helps us identify better solutions."*

Theme 3: Encouraging Active Participation

The findings indicate that interactive and student-centered instruction encouraged learners to become active contributors to the learning process rather than passive recipients of information. Classroom discussions, collaborative activities, and shared problem-solving required students to respond to new ideas, reconsider their initial viewpoints, and refine their thinking through continuous dialogue. Such learning experiences fostered intellectual flexibility, receptiveness to feedback, and greater confidence in adapting to diverse perspectives.

> *"Classes that emphasize discussions and interactive activities encourage me to think spontaneously, contribute my ideas, and adapt to different viewpoints shared by my classmates."*

> *"Interactive learning has taught me that my first answer is not always the best one. Listening to feedback from others helps me improve my ideas and arrive at better solutions."*

Question 3. *Looking back on your learning experiences, how have your instructors' teaching approaches prepared you to meet the expectations of today's technology-driven and innovation-oriented workplaces?*

Theme 1: Learning through Authentic Experiences

Authentic learning experiences emerged as an important contributor to students' confidence and professional readiness. Activities that mirrored workplace situations enabled learners to apply scientific concepts beyond theoretical discussions, requiring them to make decisions, solve practical problems, and reflect on the consequences of their actions. Engaging in these realistic learning contexts allowed students to view scientific knowledge as a tool for practice rather than memorization, strengthening their confidence in handling future academic and career-related responsibilities.

> *"Activities based on real-life scenarios make me feel as though I am already working in a professional setting, helping me understand how scientific concepts apply beyond the classroom."*

> *"Simulations and practical exercises give me opportunities to make my own decisions, allowing me to build confidence by applying what I have learned instead of simply studying the theory."*

Theme 2: Competence through Applied Performance

Students associated meaningful skill development with instructional activities that required them to demonstrate, rather than simply recall, what they had learned. Performance-based tasks and authentic problem-solving experiences challenged learners to apply scientific knowledge, justify their reasoning, and produce tangible outputs similar to those expected in professional settings. Such experiences strengthened their technical competence while reinforcing the analytical and practical abilities needed to navigate workplace demands.

> "*Performance-based activities expose me to tasks that resemble actual workplace responsibilities, allowing me to develop skills beyond theoretical knowledge."*

"Problem-solving assessments require me to think analytically, explain my reasoning, and justify my decisions—skills that I believe are essential in the workplace."

Theme 3: Growth through Constructive Guidance

The findings suggest that continuous guidance from instructors and peers fostered a learning environment where improvement was viewed as an ongoing process rather than a final outcome. Feedback encouraged students to revisit their work, recognize areas for refinement, and incorporate suggestions that strengthened the quality of their outputs. This cycle of reflection and revision not only enhanced their academic performance but also reinforced their confidence in meeting the expectations of professional practice.

"Feedback from my instructor helps me recognize where I need to improve and motivates me to produce better work instead of becoming discouraged."

"The suggestions and corrections I receive from my instructors and classmates allow me to refine my outputs, making me more confident that my work can meet professional standards."

5. Discussion

The findings indicate that science education in the Zamboanga Peninsula plays a meaningful role in fostering students' industry-relevant innovative competencies. Central to this development is the integration of social learning processes, where knowledge and skills are acquired through continuous interaction with instructors, peers, and the broader learning environment rather than through individual learning alone.

Social Learning Theory posits that learning is fundamentally shaped by observation, modeling, and social interaction. Individuals develop new knowledge, behaviors, and attitudes by attending to the actions of others, interpreting their experiences, and incorporating those observations into their own practices (Krishna et al., 2024). Beyond imitation, the theory emphasizes that learning is reinforced through feedback, reflection, and the perceived value of observed behaviors, enabling learners to adapt and refine their competencies over time (Rumjaun & Narod, 2025).

This theoretical perspective was reflected in the participants' experiences. Students attributed their development not only to classroom instruction but also to collaborative discussions, peer interactions, shared problem-solving, and continuous feedback. These social learning opportunities encouraged learners to exchange ideas, evaluate alternative perspectives, and refine their thinking, ultimately strengthening competencies such as creativity, adaptability, critical thinking, and innovation. Rather than emerging from isolated learning experiences, these competencies evolved through sustained engagement with the people and practices that characterized their science classrooms.

The findings further suggest that AI has become an additional source of observational learning within science education. Applications such as ChatGPT, Gemini, and Google's AI features exposed students to structured explanations, alternative solutions, and model responses that informed how they approached scientific tasks. Although AI does not function as a human instructor, participants interacted with its outputs in ways that closely resemble the observational processes described in Social Learning Theory, using AI-generated guidance to evaluate ideas, refine strategies, and improve their academic performance.

The role of AI identified in this study aligns with the work of Zhou and Schofield (2024), who argued that AI is particularly valuable in supporting foundational learning by helping students acquire the essential knowledge required for more advanced learning tasks. Participants similarly emphasized that AI simplified complex scientific concepts through step-by-step explanations, concise summaries, and immediate feedback, enabling them to establish a stronger conceptual foundation before engaging with more challenging academic activities. By reducing unnecessary cognitive demands, AI allowed students to devote greater attention to analysis, reasoning, and other higher-order cognitive processes essential for innovation and scientific learning.

Social Learning Theory also recognizes learners as active participants who interpret, evaluate, and regulate what they observe rather than merely imitating the behaviors of others (Saka, 2025). This perspective was evident in the present study, where students used AI-generated explanations and recommendations as references for independent learning. Instead of accepting AI responses uncritically, participants adjusted their learning strategies, explored additional resources, and regulated the pace of their learning according to their academic needs. These practices illustrate how AI-supported observation can foster learner autonomy and adaptability while encouraging greater responsibility for one's own learning.

A similar pattern emerged in students' interactions with their science instructors. Participants attributed their creative thinking and problem-solving abilities to instructional approaches that emphasized inquiry, discussion, and experiential learning. Classroom demonstrations, guided investigations, and collaborative activities exposed students to different ways of approaching scientific problems, allowing them to internalize effective learning strategies and apply them in new situations. Creativity, therefore, developed not only from individual effort but also from continuous engagement with meaningful instructional experiences.

The findings likewise reinforce the pivotal role of teachers as facilitators of learning. Effective instruction extends beyond the delivery of content and involves creating opportunities for students to question assumptions, analyze evidence, and construct deeper understanding (Rahma & Istanto, 2025). Teachers who model systematic reasoning, provide timely guidance, and encourage reflective dialogue help learners develop more disciplined approaches to scientific inquiry (Feri et al., 2022). Collaborative classroom interactions further enrich this process as students refine their ideas, consider alternative viewpoints, and strengthen their reasoning through feedback and shared learning experiences (Darwin, 2025).

These learning experiences are particularly significant in light of contemporary workforce expectations. Modern industries increasingly seek graduates who can apply knowledge in authentic contexts while demonstrating critical thinking, analytical problem-solving, adaptability, and effective collaboration in rapidly changing environments (Koch et al., 2025). Technical expertise alone is no longer sufficient; employers also value individuals who can learn continuously, respond to uncertainty, and work productively with others.

Taken together, the findings suggest that science education can cultivate these competencies by embedding social learning principles within both AI-assisted and classroom-based instruction. AI expands opportunities for observation, guided practice, and self-regulated learning, while teachers and peers provide the social interactions that sustain reflection, collaboration, and feedback. The integration of these learning experiences creates an environment in which students develop not only scientific knowledge but also the innovation-oriented competencies and workplace capabilities required in technology-driven industries.

6. Conclusion

The findings demonstrate that the development of industry-relevant innovative competencies is deeply rooted in social learning processes, where knowledge is constructed through observation, interaction, reflection, and continuous engagement with meaningful learning experiences. Within the context of science education, students learned not only from their instructors and peers but also from AI technologies that provided explanations, demonstrations, and alternative approaches to scientific tasks. Collectively, these learning resources shaped how learners analyzed problems, generated ideas, and refined their academic practices, contributing to the development of competencies valued in both educational and professional settings.

The integration of AI and teacher-facilitated instruction created complementary learning environments that encouraged creativity, critical thinking, adaptability, collaboration, and systematic problem solving. Rather than functioning as isolated instructional tools, AI applications and classroom pedagogies reinforced one another by providing opportunities for guided practice, feedback, and reflective learning. These experiences enabled students to become more autonomous, flexible, and confident learners while strengthening capabilities that align with the expectations of contemporary, technology-driven industries.

Overall, the study underscores the importance of embedding social learning principles into AI-enhanced science education. Learning environments that intentionally integrate observation, collaboration, modeling, and constructive feedback can better prepare students to navigate complex challenges, respond to technological change, and contribute effectively to innovation-oriented workplaces.

Recommendations

Schools should integrate AI technologies as purposeful learning resources that support idea generation, conceptual understanding, and scientific problem solving. When used alongside classroom instruction, these tools can guide students in exploring alternative perspectives, developing independent learning habits, and strengthening competencies required in technology-driven industries.

Science instructors are encouraged to make their thinking processes explicit during instruction by demonstrating how scientific problems are analyzed, evaluated, and resolved. Modeling systematic reasoning enables students to observe effective approaches, apply them in their own learning, and gradually develop more disciplined and analytical ways of thinking.

Collaborative learning should be strengthened through instructional activities such as case studies, inquiry-based projects, and problem-based learning. These experiences create opportunities for students to exchange perspectives, negotiate solutions, and refine their understanding through meaningful interaction with their peers.

Assessment practices should likewise emphasize continuous improvement by incorporating timely, specific, and constructive feedback. Coupled with structured peer review, feedback can encourage learners to reflect on their work, address identified gaps, and progressively enhance both their academic performance and practical competencies.

Finally, curriculum developers should align science learning experiences with authentic workplace contexts by embedding industry-relevant scenarios, performance-based tasks, and applied problem-solving activities into the curriculum. Such learning opportunities can better prepare students to demonstrate creativity, adaptability, collaboration, and critical thinking in professional environments.

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