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Can AI aid teachers to motivate inventiveness of learners in ICT, Math, Science, and TechVoc Areas

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Abstract
Anchored in Constructivist Learning Theory and reinforced by Amabile's Componential Theory of Creativity, this study examines the manner in which artificial intelligence (AI) facilitates educators in fostering inventive capacities among learners within Information and Communication Technology (ICT), Mathematics, and Science. While extant scholarly discourse underscores AI's capability to augment personalized instruction, instantaneous feedback, and adaptive learning experiences, only a limited body of literature has scrutinized the extent to which AI shapes learners' creativity and innovative competencies in STEM-oriented instructional environments, particularly when interpreted through the perspectives of both educators and learners. This scholarly lacuna becomes increasingly evident within basic education settings, where AI implementation remains in its formative stages and exhibits inconsistent levels of comprehension and application. Employing a qualitative descriptive research design, the inquiry elicits perspectives from purposively selected ICT, Mathematics, and Science teachers (n = 10–12) who have incorporated AI-enabled instructional resources, including simulations, adaptive learning platforms, and code assistance applications, together with students (n = 6–8 per discipline) who have participated in AI-supported pedagogical experiences. Data were elicited through semi-structured interviews structured in accordance with the research objectives, emphasizing the identification of teachers' AI integration practices, learners' viewpoints, and the motivational as well as inventive outcomes associated with AI-enhanced instructional contexts. The study is anticipated to demonstrate that educators employ a diverse repertoire of AI platforms to cultivate creativity, exploratory learning, and analytical problem resolution, while simultaneously encountering impediments associated with technological accessibility, professional competency development, and congruence with curricular learning outcomes. Learners are likewise expected to regard AI-powered instructional tools as immersive and motivational, particularly because of functionalities such as real-time feedback, individualized learning activities, and interactive simulations that invigorate inventive thinking. Nevertheless, potential constraints, including cognitive burden, excessive reliance on AI, and inadequate instructional facilitation, may likewise emerge. Collectively, the anticipated findings are expected to furnish a more nuanced comprehension of how AI may be pedagogically harnessed to nurture creativity and innovation across ICT, Mathematics, and Science classrooms while simultaneously informing educational policy formulation, teacher

professional development initiatives, and the refinement of AI-supported instructional approaches aligned with constructivist and creativity-oriented pedagogical principles
Keywords : Teachers, Motivate, Inventiveness, Science.

Introduction

The accelerated progression of artificial intelligence (AI) is substantially transforming contemporary educational methodologies, particularly within Science, Mathematics, and Information and Communication Technology (SMICT) instructional settings. AI-driven technologies, including intelligent tutoring systems, adaptive learning platforms, coding assistants, and simulation-based applications, are progressively being incorporated to facilitate individualized instruction, instantaneous feedback, and immersive learning experiences (Tarun et al., 2025; Ra et al., 2025). These technological innovations are extensively recognized for their capacity to strengthen higher-order cognitive competencies and foster more profound learner engagement (Nirmala & Ravichandran, 2025; Calzada, 2024). Nevertheless, notwithstanding these advancements, a limited corpus of scholarly inquiry has scrutinized the distinctive contribution of AI in cultivating learners' motivation and inventive capacities within SMICT disciplines. This scholarly deficiency becomes increasingly conspicuous as educational institutions endeavor to determine how digital technologies can nurture creativity and innovation alongside conventional academic proficiencies (Chiu et al., 2023; Espartero et al., 2024).

The accelerated progression of artificial intelligence (AI) is substantially transforming contemporary educational methodologies, particularly within Science, Mathematics, and Information and Communication Technology (SMICT) instructional settings. AI-driven technologies, including intelligent tutoring systems, adaptive learning platforms, coding assistants, and simulation-based applications, are progressively being incorporated to facilitate individualized instruction, instantaneous feedback, and immersive learning experiences (Tarun, Du, Kannan, & Gehringer, 2025; Ra, Kim, Seo, & So, 2025). These technological innovations are extensively recognized for their capacity to strengthen higher-order cognitive competencies and foster more profound learner engagement (Nirmala & Ravichandran, 2025; Calzada, 2024). Nevertheless, notwithstanding these advancements, a limited corpus of scholarly inquiry has scrutinized the distinctive contribution of AI in cultivating learners' motivation and inventive capacities within SMICT disciplines. This scholarly deficiency becomes increasingly conspicuous as educational institutions endeavor to determine how digital technologies can nurture creativity and innovation alongside conventional academic proficiencies (Chiu et al., 2023; systematic review; Espartero, Calzada, & Prado, 2024).

Although preceding scholarly inquiries have explored AI's contribution to enhancing student achievement, optimizing assessment procedures, and facilitating differentiated instructional practices (Ruslim & Khalid, 2024; Nirmala & Ravichandran, 2025), comparatively few have specifically examined the manner in which educators incorporate AI to stimulate learners' inventiveness within SMICT classrooms. Related scholarship in Science and Mathematics indicates that educational experiences are profoundly influenced by learners' perceptions, engagement, and authentic real-world interactions, yet these dimensions are seldom associated with AI integration (Verdeflor, 2024a; Verdeflor, 2024b). Equally insufficiently examined are learners' perceptions of AI-enabled instructional experiences and the extent to which these shape their motivation to create, innovate, design, or engage in experimentation. The scarcity of documented evidence concerning educators' lived experiences alongside learners' responses signifies a substantial deficiency within the extant body of literature (Sun et al., 2023; Al Darayseh, 2024; Barrientos, 2025). This scholarly gap is further reinforced by investigations addressing instructional stress and technology-mediated pedagogical delivery, which underscore the necessity for sustained pedagogical support throughout digital educational transitions, including the implementation of artificial intelligence (Quisay & Aquino, 2024).

To address this gap, the present study sought to examine how educators employ AI-driven technologies to foster inventiveness among learners in Information and Communication Technology (ICT), Mathematics, and Science, while simultaneously exploring the manner in which students perceive and participate in AI-assisted instructional environments. The inquiry endeavors to encapsulate the perspectives of both educators and learners to establish a comprehensive understanding of AI's pedagogical influence. Considering the expanding incorporation of AI-enabled resources, including simulation software utilized in Science instruction, adaptive mathematical learning systems responsive to individual learner requirements, and coding assistants implemented in ICT, there exists a compelling necessity for empirical evidence regarding their influence on learner motivation and creative cognitive processes (Tarun et al., 2025; Ra et al., 2025). Correspondingly, scholarly works examining AI-supported environmental and interdisciplinary learning further emphasize AI's capacity to strengthen inquiry-based learning, informed decision-making, and creative thought processes (Dela Calzada, Tacbobo, Lualhati, et al., 2025).

Fundamental constructs underpinning this inquiry encompass AI integration within instructional practices, learner motivation, inventiveness, creativity, adaptive learning, simulation-oriented educational experiences, and the challenges encountered by educators in relation to digital implementation. These constructs exemplify the intricate interrelationship between technological innovation and pedagogical practice within contemporary learning environments while underscoring the significance of designing AI-supported instructional activities that are congruent with constructivist and creativity-centered educational principles (Amabile, 2012; Frontiers in Education, 2025; Bondoc, 2024).

The anticipated outcomes of this study encompassed evidence indicating that AI-enabled instructional technologies, when judiciously integrated into classroom practices, possess the capacity to amplify learners' motivation, stimulate intellectual curiosity, and reinforce creative problem-solving competencies. It was projected that educators would recognize both the advantages, including heightened learner engagement and expanded opportunities for exploratory learning, and the constraints associated with professional training, technological accessibility, and curricular congruence. Likewise, learners were expected to express elevated levels of interest and inventiveness facilitated through interactive simulations, individualized feedback mechanisms, and experiential digital experimentation (Frontiers in Education, 2025; Al Darayseh, 2024). These anticipated outcomes correspond with preceding scholarly works demonstrating that immersive and innovative educational environments substantially enhance student participation and academic attainment (Espartero et al., 2024; Carpio et al., 2024). Ultimately, the findings were intended to inform the refinement of future instructional methodologies, enrich theoretical scholarship concerning creativity and constructivism within AI-enhanced educational contexts, and furnish practical guidance for educators endeavoring to integrate AI meaningfully into SMICT instruction.

LITERATURE REVIEW

The incorporation of Artificial Intelligence (AI) within educational contexts has progressed considerably, exerting a transformative influence on instructional methodologies across Science, Mathematics, and Information and Communication Technology (SMICT) disciplines. As AI-driven technologies become increasingly attainable, educators are progressively integrating these resources to strengthen creativity, analytical problem-solving, and learner engagement. This review of related literature consolidates extant scholarly evidence concerning the manner in which AI facilitates inventive learning, investigates educators' instructional practices, and examines learners' motivation and creative development within AI-supported educational environments. Contemporary scholarship likewise acknowledges the emergence of AI-related implementation challenges and ethical predicaments in academic settings, particularly among ICT and Science educators (Chavez et al., 2024).

Types of AI Tools Used in Teaching STEM/ICT

Scholarly literature identifies a broad spectrum of AI technologies that reinforce SMICT education, encompassing adaptive learning platforms, intelligent tutoring systems (ITS), simulation-based environments, automated coding assistants, and generative AI applications (Holmes et al., 2022; Zawacki-Richter et al., 2019). Within mathematics instruction, AI-enhanced tutoring platforms such as DreamBox and ASSISTments furnish instantaneous feedback and individualized problem-solving activities (Pane et al., 2021). Science educators extensively employ AI-powered simulations and virtual laboratory environments that enable learners to represent and investigate intricate scientific phenomena (Chen & Tsai, 2021). In ICT education, intelligent coding environments, including machine-learning-driven autocompletion systems, reinforce algorithmic reasoning and inventive programming endeavors (Kim et al., 2023). More recent empirical findings further indicate that AI-assisted instructional environments assist learners in overcoming mathematics anxiety and diminished self-confidence (Inoferio et al., 2024), thereby reinforcing AI's expanding significance within STEM education. Collectively, these technological resources broaden instructional possibilities by facilitating individualized learning progression, encouraging experimental inquiry, and assisting learners in navigating sophisticated STEM-related tasks that have conventionally necessitated expert human guidance.

Instructional Strategies for Innovation-Driven Learning

Educators incorporate AI through diverse pedagogical approaches to cultivate learners' inventiveness, including inquiry-oriented instruction, project-based learning, and design thinking methodologies. AI technologies possess the capability to generate multiple problem variations, scaffold unfamiliar concepts, and deliver feedback that promotes iterative refinement and continuous improvement (Luckin & Cukurova, 2019). Within science instructional settings, educators utilize AI-driven simulations to facilitate hypothesis formulation and experimental inquiry beyond the limitations imposed by conventional laboratory environments (Dede et al., 2020). In mathematics education, AI supports inventive problem-solving by enabling learners to investigate multiple solution trajectories for a single mathematical challenge (Kaur & Natarajan, 2021). Educators specializing in Science and Mathematics have likewise articulated nuanced perspectives regarding generative AI, particularly in relation to its implications for academic integrity (Mundo et al., 2024). Within ICT instruction, generative AI applications and intelligent debugging assistants empower learners to prototype software applications, conceptualize algorithms, and resolve programming errors through creative exploration (Li & Xu, 2023). Collectively, these pedagogical practices illustrate AI's capacity to augment educators' instructional competence in establishing learning environments conducive to student innovation, although teachers responsible for multiple disciplinary areas report varying levels of preparedness and adaptability in utilizing such technological resources (Castro et al., 2024).

Challenges Faced by Teachers in Implementing AI.

Notwithstanding its numerous advantages, educators continue to encounter substantial impediments to the effective integration of AI within instructional practice. Predominant challenges encompass constrained technical proficiency, inadequate professional training, and apprehensions regarding excessive dependence on AI-driven technologies (Holmes et al., 2022). Educators likewise convey uncertainty concerning the formulation of AI-supported instructional activities capable of authentically fostering creativity rather than merely automating academic tasks (Zawacki-Richter et al., 2019). Limitations in technological infrastructure, including unreliable internet connectivity and insufficient institutional resources, further obstruct implementation across numerous educational contexts (Wright & Ulmer, 2020). Ethical considerations, such as algorithmic bias, data privacy, and system transparency, likewise influence educators' willingness to incorporate AI into their instructional practices (Crompton & Burke, 2021). These concerns are further substantiated by discourse-based analyses documenting educators' apprehensions regarding AI's implications for academic integrity and established classroom practices (Chavez et al., 2023; Chavez et al., 2024). Collectively, these circumstances underscore the necessity for targeted professional development initiatives and well-defined pedagogical frameworks to facilitate meaningful and effective AI integration.

Perceptions of AI Tools by Students

Learners generally exhibit favorable perceptions toward AI-enabled instructional technologies, frequently associating them with heightened engagement, individualized academic support, and strengthened self-confidence (Chan et al., 2021). Students particularly value the provision of instantaneous feedback and adaptive learning trajectories, especially within Mathematics and Science, where conceptual complexity often diminishes learning motivation (Pane et al., 2021). Within ICT education, learners commonly appreciate AI-powered coding assistants for alleviating cognitive demands and facilitating more efficient iterative refinement during programming activities (Kim et al., 2023). Empirical evidence further indicates that digitally mediated learning environments, including those influenced by AI technologies, shape communication dynamics and learner engagement, particularly in online educational settings (Cuilan et al., 2024; Chavez & Prado, 2023). Nevertheless, some learners express apprehension that excessive reliance on AI may diminish opportunities for critical thinking, particularly when technological tools furnish solutions with minimal cognitive effort (Chen & Tsai, 2021). Consequently, maintaining an appropriate equilibrium between instructional support and productive cognitive struggle remains an essential pedagogical consideration.

Enhancing Learners' Creative and Experimental Capacities.

AI-enabled instructional technologies foster inventiveness by empowering learners to conceptualize ideas, simulate prospective outcomes, and participate in open-ended experimental inquiry. Scholarly evidence within STEM education demonstrates that AI-supported learning environments enable students to formulate hypotheses, evaluate multiple iterative variations, and devise creative solutions under fewer instructional constraints (Dede et al., 2020). Generative AI models have likewise exhibited the capacity to collaborate with learners in co-constructing knowledge, thereby stimulating creativity across programming, design, and scientific modeling activities (Kaur & Natarajan, 2021). Learners likewise report heightened motivation to innovate when AI-assisted instructional experiences incorporate individualized feedback, interactive user interfaces, and opportunities for exploratory engagement (Chan et al., 2021). These attributes correspond with the foundational principles of constructivist and inquiry-based learning theories, both of which emphasize learner autonomy and creative problem-solving. Complementary scholarly findings further underscore the influence of social learning processes in shaping learners' engagement with technologically mediated instructional activities (Adalia et al., 2025).

Limitations and Risks to Inventiveness.

Conversely, AI may constrain creative development when instructional technologies become excessively prescriptive or diminish learners' autonomy. Scholarly investigations caution that automated feedback mechanisms may prioritize procedural correctness rather than fostering creative reasoning when implemented ineffectively (Holmes et al., 2022). Furthermore, certain AI-driven tutoring systems possess the potential to restrict learning trajectories, thereby limiting opportunities for divergent thinking (Crompton & Burke, 2021). More recent empirical findings likewise indicate that learners' motivation and perseverance may be influenced by external circumstances, including personal obligations and societal pressures, which may interact with technologically mediated learning environments (Garcia et al., 2025). Consequently, ensuring that AI functions as a catalyst for, rather than a substitute for, learner creativity continues to constitute a persistent educational challenge.

Existing scholarly literature indicates that AI possesses considerable potential to strengthen inventiveness, motivation, and creativity across ICT, Mathematics, and Science education. Educators utilize AI-enabled technologies to enrich experimental inquiry, scaffold analytical problem-solving, and personalize instructional experiences. Nevertheless, challenges encompassing inadequate professional preparation, ethical considerations, and the possibility of excessive automation continue to complicate its effective implementation. Learners generally demonstrate favorable responses toward AI-assisted instructional environments; however, the extent of AI's influence on creativity remains substantially contingent upon the quality of instructional design. Collectively, this review underscores the necessity for pedagogically grounded AI implementation to optimize its educational benefits for both educators and learners.

METHODS

Research design

This study adopted a qualitative descriptive research design, an approach well-suited for examining and comprehending participants' experiences, perceptions, and instructional practices pertaining to the integration of artificial intelligence (AI) within teaching and learning contexts. This research design facilitates an in-depth exploration of the manner in which educators incorporate AI-enabled technologies to stimulate inventiveness among learners in Information and Communication Technology (ICT), Mathematics, and Science (SMICT), while simultaneously examining learners' responses to AI-assisted instructional environments. Through descriptive qualitative inquiry, comprehensive data were elicited from participants' narratives, lived experiences, and reflective accounts, thereby generating meaningful insights into authentic classroom practices and patterns of learner engagement.

Population and Sampling

The study comprised two participant groups: educators and learners. The educator population consisted of ICT, Mathematics, and Science teachers who had incorporated at least one AI-assisted instructional technology, including simulation applications, adaptive learning platforms, or intelligent coding assistants. A total of 10–12 teachers were purposively selected, ensuring balanced representation across the three disciplines, specifically four Science teachers, four Mathematics teachers, and four ICT teachers. The learner population encompassed students enrolled in ICT, Mathematics, or Science classes who had participated in AI-supported instructional activities. Six to eight learners from each discipline were purposively selected to ensure that every participant possessed direct exposure to AI-assisted learning experiences. The study employed purposive sampling, a non-probability sampling strategy that facilitates the deliberate selection of participants according to predetermined criteria aligned with the objectives of the inquiry. Employing this sampling approach ensured that both educators and learners were capable of providing substantial insights regarding the integration of AI technologies within SMICT classrooms and their influence on learners' motivation and inventive capacities.

Instrument

Data for this study were elicited through semi-structured interviews, an instrument that affords flexibility while ensuring comprehensive coverage of essential research topics. Two distinct interview guides were formulated: one intended for educators and another for learners. The teacher interview guide comprised questions concerning the AI-enabled technologies they employ, the strategies through which they incorporate AI to cultivate creativity, experimentation, and analytical problem-solving, as well as the challenges they encounter when implementing AI to facilitate innovation-oriented instruction. Conversely, the learner interview guide concentrated on students' perceptions of AI-assisted technologies, the influence of AI on their motivation to innovate, create, and engage in experimentation, together with the specific features of AI-supported instructional activities—including feedback mechanisms, interactivity, personalization, and simulation-based experiences—that either enhance or constrain their inventive capacities. The semi-structured interview format enabled participants to furnish comprehensive explanations, illustrative examples, and reflective insights, thereby facilitating the acquisition of rich, meaningful qualitative data. Table 1 presents the compilation of interview guide questions utilized in this research study.

Data Gathering Procedure

Data were gathered through a systematic procedural framework to ensure accuracy, adherence to ethical standards, and minimal interference with the participants' instructional environment. Approval was initially secured from the appropriate school authorities, after which informed consent was obtained from all participants, with particular emphasis placed on confidentiality and the voluntary nature of participation. Individual interviews were subsequently conducted with educators, whereas focus interviews involving small groups of learners were arranged at mutually convenient schedules to prevent disruption of regular instructional activities. Each interview session was carried out in a quiet and conducive setting, audio-recorded with the participants' consent, and complemented by field notes documenting non-verbal behaviors and relevant contextual observations. Upon completion of the data collection process, all interview recordings were transcribed verbatim to preserve the accuracy, completeness, and integrity of the qualitative data for subsequent analysis.

Data Analysis

The collected data were examined through thematic analysis, a qualitative analytical approach employed to identify, examine, and articulate recurring patterns or themes embedded within the dataset. The analytical procedure commenced with a familiarization stage, during which the researchers repeatedly reviewed the interview transcripts to attain a comprehensive understanding of the participants' narratives. Subsequently, salient statements, concepts, and ideas were identified and assigned preliminary codes. Conceptually related codes were then consolidated into categories, from which overarching themes were generated based on the recurring patterns and interpretative insights emerging from the data. These themes were thereafter interpreted in relation to the research objectives, establishing connections between the findings and the theoretical foundations of

Constructivist Learning Theory and Amabile's Componential Theory of Creativity. To reinforce the credibility, trustworthiness, and accuracy of the analytical process, member checking was undertaken with selected participants. Through this systematic analytical procedure, the study sought to generate comprehensive insights into the manner in which educators integrate AI-enabled technologies to cultivate inventiveness and how learners perceive, experience, and respond to AI-assisted instruction within Information and Communication Technology, Mathematics, and Science classrooms.

RESULTS

Research Objectives 1. To identify how teachers integrate AI tools to encourage inventiveness among ICT, Mathematics, and Science learners.

Question No. 1. What specific AI tools or platforms do teachers utilize in teaching SMICT subjects?

1.1 AI Facilitates Conceptual Understanding

Four (4) respondents conveyed that they incorporated ChatGPT into classroom instruction to facilitate algorithm explanations and pseudo-code development. According to the participants, the platform proved particularly beneficial for novice learners because it presented concepts through comprehensible analogies that are often absent from conventional textbooks, such as relating sorting algorithms to familiar everyday activities, thereby making abstract principles more accessible. Nevertheless, they acknowledged that ChatGPT occasionally generated explanations that appeared plausible despite containing subtle inaccuracies or inefficient procedures. Consequently, they no longer regarded the tool as an authoritative instructional source but rather as a supplementary learning aid. Furthermore, the respondents emphasized that students were required to validate AI-generated outputs by executing the pseudo-code within their Integrated Development Environment (IDE), comparing the results with classroom notes, and identifying inconsistencies or misconceptions. Learners also prepared brief reflective responses describing the concepts accurately explained by the AI and those that were misinterpreted. This instructional strategy transformed AI utilization into a critical-thinking activity, encouraging learners to scrutinize, evaluate, and refine information rather than depend on AI-generated responses uncritically.

"I incorporated ChatGPT during our discussions on algorithms and pseudo-code. It is particularly beneficial for beginners because it explains concepts through relatable analogies that are rarely found in textbooks, such as comparing sorting algorithms with everyday routines, making the lessons easier to comprehend."
"Whenever students use ChatGPT, they are required to validate its output by running the pseudo-code in our Integrated Development Environment (IDE), comparing the results with our classroom discussions, and identifying any inaccuracies or misconceptions."

1.2 AI Supports Mathematical Reasoning

Four (4) respondents indicated that they employed Photomath and Microsoft Math Solver as supplementary homework resources, allowing students to capture mathematical problems and obtain step-by-step solution procedures. They emphasized that these applications were intended solely for verifying completed work rather than replacing independent problem-solving. Accordingly, students were instructed to document the particular solution step that enhanced their understanding instead of reproducing the entire explanation. The respondents observed that these AI-assisted applications provided immediate feedback, strengthened procedural fluency, and enabled learners to recognize and rectify errors promptly. However, they likewise noted that some students bypassed the reasoning process by immediately scanning problems, particularly when experiencing fatigue or time constraints. To address this tendency, the teachers introduced a gamified reflective activity requiring learners to annotate the specific stage at which they encountered difficulty, identify their misconception, and explain how the application clarified the concept. Through this strategy, the AI tools functioned as mechanisms for diagnosing learners' thinking processes rather than serving merely as convenient shortcuts.

"We integrated Photomath and Microsoft Math Solver as supplementary homework resources, allowing students to scan mathematical problems and examine the step-by-step solution process."
"I require learners to identify and document the specific solution step that improved their understanding instead of merely reproducing the application's entire explanation."

1.3 AI Enhances Inquiry Learning

Four (4) respondents reported utilizing PhET simulations for conceptual exploration while integrating an AI chatbot to facilitate follow-up questioning. After manipulating variables within the PhET simulation environment, students collaborated in groups to pose conceptual questions to a classroom ChatGPT bot. The respondents assessed both the quality of learners' questions and their ability to synthesize the AI-generated responses. Moreover, they explained that this instructional approach promoted learner accountability by encouraging students to articulate areas of confusion and critically verify AI-generated explanations. The integration of simulation technologies with AI-assisted dialogue likewise strengthened metacognitive competencies, enabling learners to recognize misconceptions, evaluate the credibility of AI responses, and refine their conceptual understanding through continuous exploration, questioning, and critical evaluation.

"We utilized PhET simulations for conceptual exploration and complemented them with an AI chatbot to facilitate follow-up conceptual questioning."
"This instructional strategy encourages students to take responsibility for their learning by expressing areas of confusion and critically validating the explanations generated by AI."

Question No. 2 How do teachers incorporate AI to support creativity, experimentation, and problem-solving?

2.1 **AI Accelerates Creative Prototyping**

Four (4) respondents expressed that they integrated AI code assistants during website and simple application development activities, enabling students to debug programs or generate initial coding templates. According to the participants, this instructional practice minimizes learners' apprehension toward beginning programming tasks by eliminating the challenge of facing an empty coding workspace. With an initial framework readily available, students can immediately visualize and develop their intended outputs instead of becoming preoccupied with syntax-related errors or preliminary program setup. Furthermore, the respondents observed stronger collaborative interactions among learners, as student groups compared AI-generated outputs, critically evaluated alternative suggestions, and synthesized multiple ideas, treating AI as a shared creative partner. They emphasized that AI transforms the classroom atmosphere by replacing learners' self-doubt with confidence, thereby cultivating the mindset essential for creativity and analytical problem-solving.

"When students develop websites or simple applications, they utilize AI-powered coding assistants to debug programs or generate preliminary coding templates. This enables them to concentrate more on developing creative ideas than on resolving basic coding issues."
"I have also observed stronger collaboration because student groups compare AI-generated outputs, evaluate different suggestions, and combine the most effective ideas, treating AI as a shared resource that stimulates creativity."

2.2 AI Promotes Analytical Problem-Solving

Four (4) respondents indicated that AI assumes responsibility for repetitive skill drills and routine computational exercises, allowing classroom time to be redirected toward intellectually demanding learning activities requiring data interpretation, evidence-based justification, and authentic problem-solving. They observed that students entered class with greater enthusiasm and curiosity because they were no longer mentally exhausted by repetitive practice activities. Moreover, the respondents explained that instructional emphasis shifted from merely obtaining the correct answer toward understanding why a particular solution was appropriate and what implications it carried. Consequently, students demonstrated increasingly analytical thinking by posing deeper questions, comparing multiple solution strategies, and articulating their reasoning with greater confidence. The participants emphasized that AI does not replace mathematical reasoning; instead, it creates opportunities for richer, more meaningful cognitive engagement.

"By allowing AI to manage repetitive skill drills and routine computation exercises, I can devote more instructional time to authentic learning tasks that require students to interpret information, justify their decisions, and solve real-world problems."
"My instructional focus has shifted from simply obtaining the correct answer to helping students understand why a solution works and what it signifies, enabling them to become more analytical in their mathematical reasoning."

***2.3* AI Strengthens Scientific Inquiry**
Four (4) respondents shared that when learners raised science-related questions during classroom instruction, AI provided guiding prompts rather than direct answers. According to the participants, this approach encouraged students to reconsider their hypotheses, reexamine overlooked variables, and investigate alternative explanations before drawing conclusions. Rather than becoming discouraged by unexpected or confusing results, learners became more willing to explore multiple possibilities throughout the investigative process. The respondents further explained that AI-guided questioning nurtures scientific reasoning by encouraging students to think like investigators instead of relying on assumptions. In addition, they emphasized that the AI's immediate responses sustained learners' momentum, enabling them to examine new ideas without unnecessary interruptions and fostering more natural inquiry-based learning experiences. Through this scaffolded approach, students became increasingly curious, perceiving scientific problems as multidimensional investigations instead of questions with only a single correct answer.

“When students raise science-related questions during class, AI provides guiding prompts rather than direct answers, encouraging them to reconsider their hypotheses, revisit overlooked variables, and investigate alternative explanations."
"Because AI responds immediately, students maintain their momentum and can investigate new ideas without delay, making inquiry-based learning more natural and engaging."

Question No. 3. What challenges do teachers face when using AI for innovation-driven instruction?

3.1 Balancing AI with Fundamentals
Four (4) respondents expressed that maintaining an appropriate balance between AI-assisted coding activities and teaching fundamental programming concepts remains a significant challenge. They explained that AI tools can rapidly generate complete solutions, which may inadvertently shorten the learning process by reducing students' opportunities to develop essential coding competencies independently. Consequently, they intentionally design learning activities that require students to critically examine AI-generated outputs by explaining, modifying, optimizing, or debugging the suggested solutions instead of merely reproducing them. Furthermore, the respondents emphasized that excessive dependence on AI may create deficiencies in foundational knowledge, particularly when learners complete assessments without AI assistance or encounter unfamiliar programming problems that AI cannot immediately resolve. They also devote additional time to scaffolding instructional tasks, developing carefully structured prompts that balance learner autonomy with instructional guidance while emphasizing the reasoning process rather than simply producing functional code.

"Balancing AI-assisted programming activities with the teaching of fundamental coding concepts is challenging because AI can quickly generate complete solutions, which may unintentionally shorten the learning process."
"Excessive reliance on AI can create gaps in students' foundational knowledge, particularly when they complete assessments without AI support or encounter unfamiliar programming tasks that require independent reasoning."

3.2 Overdependence on AI Responses

Four (4) respondents indicated that students frequently perceive AI applications as answer-generating tools rather than instructional resources that facilitate meaningful learning. According to the participants, learners often rely on AI to obtain immediate solutions instead of formulating hypotheses, investigating alternative approaches, or reasoning systematically through problems. They further observed that students commonly accept AI-generated responses without critically evaluating their accuracy, efficiency, or applicability across varying situations. Moreover, the respondents explained that determining learners' genuine understanding becomes increasingly difficult because AI-produced outputs can conceal conceptual deficiencies, making it more challenging to identify areas requiring instructional intervention. They emphasized that without carefully designed instructional strategies, AI may inadvertently diminish cognitive engagement by transforming an otherwise meaningful learning experience into a passive activity.

“Students frequently use AI as an answer-generating tool instead of a learning resource, relying on immediate solutions rather than testing hypotheses, exploring alternative approaches, or reasoning through problems independently."
"I also find it difficult to determine students' genuine understanding because AI-generated responses can conceal learning gaps, making it more challenging to identify where additional instructional support is needed."

3.3 Limited Teacher AI Proficiency
Four (4) respondents shared that they occasionally encounter AI-powered simulations and instructional platforms equipped with sophisticated features, including customizable parameters, multi-layered modeling functions, and integrated data analysis modules that they have not yet fully explored or mastered. According to the participants, this limited familiarity causes hesitation in fully incorporating these technologies into classroom instruction because they are concerned about resolving technical issues, responding confidently to students' inquiries, and ensuring that the activities remain aligned with intended learning outcomes. Furthermore, the respondents acknowledged that they frequently utilize only the basic functionalities of these AI tools, thereby restricting opportunities for deeper learner engagement and more extensive experimentation. They also explained that considerable preparation time is often devoted to creating instructional guides and tutorials for students, which may reduce overall instructional efficiency.

"I occasionally encounter AI simulations and instructional tools equipped with advanced capabilities, such as customizable parameters, multi-layered modeling, and integrated data analysis features that I have not yet fully mastered."
"Because of my limited familiarity with these advanced functions, I often rely only on the basic features, which reduces opportunities for deeper student engagement and meaningful experimentation."

Research Objectives 2. To explore learners’ motivation and inventiveness when exposed to AI-assisted learning environments.

Question No. 1. How do learners perceive the use of AI tools in ICT, Math, and Science classes?

1.1 AI Stimulates Learning Curiosity
Two (2) respondents expressed that they perceived AI-assisted tools as both beneficial and challenging within ICT, Mathematics, and Science classes. According to the participants, AI enhances learning by providing hints, step-by-step guidance, and alternative solution strategies that encourage experimentation, stimulate curiosity, and promote deeper cognitive engagement. They particularly appreciated AI-assisted coding support through debugging assistance and code improvement suggestions, although they acknowledged occasionally becoming overly dependent on these recommendations without fully comprehending the underlying concepts. Furthermore, the respondents explained that one recurring concern involves AI generating multiple possible solutions for a single problem. Although they valued being exposed to diverse approaches, the abundance of alternatives occasionally became overwhelming, making it difficult to determine which solution was the most appropriate,

efficient, or aligned with their teachers' expectations. This finding highlights the importance of teacher guidance in helping learners critically evaluate AI-generated responses and select the most suitable approach.

"I generally perceive AI tools as both beneficial and challenging. They provide helpful hints, step-by-step guidance, and alternative approaches that encourage me to experiment, become more curious, and think more deeply about the lesson."
"One challenge I often encounter is when AI presents several possible solutions to the same problem. Although I appreciate having different options, I sometimes become uncertain about which solution is the most effective, the most efficient, or the one expected by my teacher."

1.2 AI Strengthens Learning Confidence
Five (5) respondents expressed that AI was particularly valuable for improving conceptual understanding and planning experimental activities. They explained that they frequently asked AI why scientific reactions occurred or why certain processes behaved differently, encouraging them to reconsider their assumptions and investigate alternative explanations. The participants further indicated that AI enabled them to mentally simulate experiments before performing actual laboratory activities, thereby reducing anxiety and allowing them to organize experimental procedures more confidently. Consequently, they felt more prepared, less apprehensive, and better equipped to conduct scientific investigations.

"I find AI especially valuable for strengthening my conceptual understanding and planning experiments. Asking AI why a reaction slows down or why something happens encourages me to reconsider my assumptions and explore alternative explanations."
"AI allows me to mentally simulate experiments before conducting them in the laboratory, making practical activities less stressful and helping me prepare each step more confidently."

1.3 AI Requires Teacher Guidance
Two (2) respondents expressed that they occasionally became overly confident by assuming that AI-generated responses were automatically accurate, reminding them of the importance of validating their own understanding. They described experiencing a constant balance between the convenience offered by AI and the need for genuine conceptual comprehension. Although AI efficiently provides solutions, they acknowledged that this convenience may encourage passive learning, where procedures are followed without fully understanding the underlying reasoning. Furthermore, the respondents emphasized that AI lacks the depth and clarity of human instruction, particularly in Mathematics, making teacher guidance indispensable for connecting procedural knowledge with conceptual understanding. They recognized that while AI can simplify problem-solving, it cannot replace educators in developing reasoning skills, conceptual mastery, and independent critical thinking.

"Sometimes I become overly confident and assume that AI-generated answers are automatically correct, but this reminds me that I still need to verify my own understanding."
"Although AI makes solving mathematical problems easier, it cannot provide the same depth of explanation as my teacher. I still need my teacher's guidance to understand the concepts instead of simply following the procedures."

Question No. 2. In what ways does AI influence their motivation to innovate, design, create, or experiment?

2.1 AI Inspires Creative Thinking
Four (4) respondents expressed that AI serves as a catalyst for creativity and experimentation by introducing diverse approaches to solving problems. According to the participants, even when they do not directly adopt AI-generated solutions, exposure to multiple suggestions broadens their perspectives, stimulates new ideas, and encourages divergent thinking. They explained that this experience reduces the psychological fear of making mistakes, making them more willing to explore unconventional approaches and experiment with greater confidence. Furthermore, the respondents shared that AI strengthens their creative self-confidence by encouraging

them to combine AI-generated suggestions with their own prior knowledge to develop original solutions. They also noted that AI promotes metacognitive awareness by helping them evaluate why certain approaches are effective while others are less suitable. As a result, AI-generated suggestions become starting points for iterative problem-solving, allowing learners to mentally visualize possible outcomes, reflect on alternative strategies, and continuously refine their own ideas.

"AI encourages me to think more creatively by presenting different ways to approach a problem, allowing me to explore ideas that I might not have considered on my own."
"AI also strengthens my confidence to create original solutions because I can combine its suggestions with my own knowledge, reflect on different possibilities, and improve my ideas through continuous refinement."

2.2 AI Encourages Active Experimentation
Two (2) respondents expressed that AI motivates them to innovate by enabling rapid experimentation and continuous iteration. They explained that AI allows them to test multiple versions of a program, experimental procedure, or design within a short period, eliminating unnecessary delays during the learning process. The participants further indicated that AI provides immediate feedback, enabling them to recognize mistakes, revise their work, and improve their outputs independently. Moreover, they emphasized that exposure to multiple solution strategies broadens their thinking, encourages divergent problem-solving, minimizes the fear of failure, and promotes low-risk experimentation. These experiences collectively strengthen their creative confidence, deepen their conceptual understanding, and enhance their metacognitive awareness, making them more willing to design, create, and innovate.

"AI motivates me to experiment and innovate because it allows me to quickly test different versions of a code, experiment, or design while providing immediate feedback that helps me improve my work."
"By presenting several possible solutions, AI broadens my thinking, encourages me to explore different approaches, and reduces my fear of making mistakes during experimentation."

2.3 AI Promotes Collaborative Innovation
Three (3) respondents expressed that AI enhances their motivation to innovate by supporting both independent and collaborative problem-solving experiences. According to the participants, AI facilitates rapid experimentation, provides immediate feedback, and offers multiple solution strategies that stimulate idea generation while minimizing the fear of failure. Furthermore, they explained that AI serves as a common reference point during group discussions, making collaborative interactions more organized, focused, and productive. They also emphasized that AI allows group members to independently test ideas before comparing their findings, encouraging balanced participation, constructive evaluation, and reflective teamwork. Collectively, these experiences strengthen learners' creative confidence, conceptual understanding, and metacognitive awareness, increasing their willingness to explore, design, and innovate both individually and collaboratively.

"AI increases my motivation to innovate because it supports both independent learning and collaborative problem-solving, allowing us to generate and improve ideas together."
“AI provides our group with a common point of reference during discussions, enabling us to evaluate different ideas, compare our results, and collaborate more effectively while developing creative solutions."

Question No. 3. What aspects of AI-assisted activities (feedback, interactivity, personalization, simulation) enhance or limit their inventiveness?

3.1 AI Encourages Exploratory Thinking
Five (5) respondents expressed that AI systems providing hints instead of complete solutions encourage them to engage more actively with learning tasks. Rather than passively accepting answers, they are prompted to analyze problems independently, formulate multiple solution strategies, compare possible outcomes, and evaluate the strengths and limitations of each approach. According to the participants, this process strengthens divergent

thinking, an essential component of inventiveness. Furthermore, they explained that the immediate feedback generated by AI serves as a rapid mechanism for evaluating their ideas, allowing them to determine whether a strategy is effective and revise it accordingly. This continuous cycle of feedback minimizes the fear of making mistakes, encourages iterative problem-solving, and promotes experimentation. Consequently, learners become more willing to develop alternative strategies, refine their thinking, and investigate unconventional solutions that they might otherwise hesitate to pursue in traditional classroom settings.

"When AI provides hints instead of complete answers, it encourages me to engage actively with the problem, develop different solution strategies, and think independently rather than simply accepting the response."

"The instant feedback from AI allows me to test my ideas immediately, recognize whether they are effective, and adjust my approach, making me more confident to experiment with alternative solutions."

3.2 AI Restricts Creative Exploration

Four (4) respondents shared that AI-assisted simulations may limit inventiveness when they are excessively structured or restricted to predetermined learning pathways. They explained that highly prescriptive simulations confine learners to the options established by the system, reducing opportunities to investigate unconventional ideas or explore alternative approaches independently. Moreover, the respondents noted that AI's ability to generate optimal solutions almost instantly may foster cognitive dependency among learners. Instead of critically evaluating different possibilities, some students become inclined to rely on AI-generated recommendations as the preferred solution. According to the participants, prolonged dependence on AI may gradually reduce problem-solving initiative, originality, and willingness to formulate independent hypotheses, ultimately encouraging a more passive approach to learning.

"*When AI simulations are highly structured, I become restricted to the learning paths established by the system, limiting my opportunity to explore creative and unconventional approaches."*

"Knowing that AI can immediately generate the most effective solution sometimes makes me depend on its recommendations instead of thinking critically about alternative possibilities."

3.3 AI Personalizes Learning Challenges

Two (2) respondents expressed that AI-assisted personalization enhances inventiveness by adjusting learning activities according to their individual pace and competency level. They explained that appropriately challenging tasks prevent boredom caused by overly simple activities while also minimizing frustration resulting from excessively difficult tasks. Maintaining this optimal level of challenge encourages them to experiment with diverse strategies and take intellectual risks that contribute to creative thinking. Furthermore, the respondents shared that personalized AI environments support self-directed learning by enabling them to recognize opportunities for innovation instead of merely following predetermined procedures. They also emphasized that the gradual increase in task complexity strengthens both confidence and competence, making them more willing to investigate unconventional solutions and apply creative approaches to problem-solving.

"AI that adapts learning activities to my pace and skill level provides an appropriate level of challenge, encouraging me to experiment with different strategies without becoming either bored or frustrated."

"Personalized AI also supports self-directed learning by helping me recognize opportunities to innovate instead of simply following prescribed procedures, giving me greater confidence to explore creative solutions."

DISCUSSION

The findings of the present study demonstrate that artificial intelligence (AI) technologies substantially reinforce both instructional practices and learner engagement within Information and Communication Technology (ICT), Mathematics, and Science classrooms, thereby exhibiting strong congruence with the foundational principles of Constructivist Learning Theory. This theoretical perspective posits that learners actively construct knowledge through authentic experiences, reflective cognition, and social interaction instead of passively acquiring information. Educators' integration of AI platforms, including ChatGPT, Photomath, Microsoft Math Solver, and PhET simulations, exemplifies this constructivist orientation, as these technologies function as instructional scaffolds that encourage learners to investigate, experiment, and critically appraise potential solutions. For instance, requiring students to validate ChatGPT-generated pseudo-code or document the procedural steps learned from Math Solver actively engages them in reflective and metacognitive processes, enabling conceptual understanding through guided inquiry rather than mechanical memorization. Likewise, integrating PhET simulations with AI chatbots encourages learners to formulate questions, articulate misconceptions, and synthesize AI-generated explanations, thereby fostering a continuous cycle of exploration, inquiry, critical evaluation, and conceptual refinement that is consistent with constructivist learning principles.

From the perspective of Amabile's Componential Theory of Creativity, the findings further indicate that AI technologies strengthen the fundamental dimensions underpinning creativity and innovation, namely domain-relevant competencies, creativity-relevant cognitive processes, and intrinsic motivation. Participants reported that AI facilitates rapid prototyping and analytical problem-solving by minimizing procedural barriers, thereby allowing learners to concentrate on higher-order reasoning and creative experimentation. For example, AI-assisted coding platforms provide instructional scaffolds that reduce the cognitive demands associated with programming syntax and system configuration, enabling learners to devote greater attention to idea generation, collaborative engagement, and iterative solution refinement. Such instructional experiences cultivate creative self-efficacy and divergent thinking, both of which are indispensable components of innovative learning. Similarly, learners perceived AI-generated alternative solutions as valuable stimuli for generating new ideas, reducing apprehension toward failure, and encouraging iterative experimentation, thereby strengthening their intrinsic motivation to explore, innovate, and create.

The findings addressing the first research objective, which sought to identify how educators integrate AI technologies to cultivate learners' inventiveness, reveal that teachers deliberately employ AI as an instructional scaffold while preserving learners' critical engagement. By requiring students to verify AI-generated outputs, justify their reasoning, and critically evaluate proposed solutions, educators position AI as a cognitive partner rather than a passive provider of answers. This pedagogical strategy not only strengthens learners' inventive capacities but also mitigates potential concerns associated with excessive dependence on AI and deficiencies in foundational knowledge. Nevertheless, the findings likewise reveal persistent implementation challenges, including maintaining equilibrium between AI-assisted instruction and the teaching of core disciplinary concepts, as well as educators' hesitation to utilize advanced AI functionalities because of limited technical proficiency. These findings underscore the necessity for sustained professional development initiatives and carefully structured instructional designs that facilitate effective AI integration.

The second research objective, which explored learners' motivation and inventiveness within AI-assisted instructional environments, the findings indicate that learners generally perceive AI as a catalyst for creative engagement and intellectual exploration. AI technologies were found to stimulate curiosity, alleviate learning anxiety, and strengthen scientific reasoning together with analytical problem-solving, thereby increasing learners' willingness to experiment, iterate, and refine their ideas. Furthermore, instantaneous feedback, personalized learning experiences, and collaborative instructional scaffolds contributed to the development of learners' metacognitive awareness, enabling them to evaluate and improve their learning strategies. These findings exhibit strong alignment with both Constructivist Learning Theory and Amabile's Componential Theory of Creativity. Nevertheless, participants also identified several limitations, including excessively rigid AI simulations that constrained exploratory learning and insufficient conceptual explanations that necessitated continued teacher intervention to transform AI-supported activities into meaningful conceptual understanding.

Findings suggest that, when pedagogically implemented with deliberate planning, AI technologies function simultaneously as cognitive and creative instructional scaffolds. Anchored in constructivist principles, AI promotes active knowledge construction, exploratory experimentation, collaborative learning, and reflective thinking while simultaneously strengthening the essential dimensions of creativity identified within Amabile's theoretical framework. This convergence of theoretical perspectives demonstrates the considerable potential of AI-assisted instruction to cultivate inventive thinking, sustained learner motivation, and reflective learning within STEM classrooms, provided that instructional practices achieve an appropriate balance among learner autonomy, educator guidance, and critical cognitive engagement.

CONCLUSION

The findings of the study indicate that artificial intelligence (AI) technologies perform a substantial role in fostering learners' inventiveness while reinforcing educational experiences within Information and

Communication Technology (ICT), Mathematics, and Science. Educators reported utilizing platforms such as ChatGPT, Photomath, Microsoft Math Solver, and PhET simulations to facilitate conceptual understanding, experimental inquiry, and creative problem-solving. AI functioned as an instructional scaffold by providing immediate feedback, multiple solution pathways, and personalized learning support, thereby enabling learners to concentrate on innovation, iterative reasoning, and collaborative exploration. Learners likewise demonstrated predominantly favorable perceptions toward AI-assisted instruction, emphasizing its capacity to stimulate curiosity, alleviate learning anxiety, strengthen confidence, and encourage the exploration of ideas, prototype development, and reflective cognitive engagement.

Despite these educational advantages, the findings likewise revealed several implementation challenges. Educators encountered difficulties in balancing AI integration with the instruction of foundational concepts, addressing learners' excessive dependence on AI-generated responses, and effectively utilizing sophisticated AI functionalities. Similarly, learners reported that highly structured or solution-oriented AI simulations occasionally constrained creative exploration, whereas insufficient instructional guidance could contribute to passive learning behaviors and conceptual misconceptions. Overall, the findings suggest that thoughtfully implemented AI-assisted learning environments provide meaningful opportunities for enriched learner engagement, individualized experimentation, and enhanced creative thinking. Nevertheless, carefully designed instructional strategies, continuous pedagogical guidance, and systematic monitoring remain indispensable for maximizing the educational benefits of AI while minimizing its potential limitations...

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