Integration of Artificial Intelligence Tools in Inquiry-Based Physics Instruction for Grade 10 in Public Secondary Schools of Quezon Province

Windel R. Nogot

University of Perpetual Help System- Dalta, Las Piñas City, Philippines

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ABSTRACT

This study examined the integration of artificial intelligence (AI) tools in inquiry-based Physics instruction among Grade 10 teachers in public secondary schools under the Schools Division Office of Quezon Province, Philippines. Employing a convergent parallel mixed-methods design, the research gathered quantitative data from 252 teachers through surveys and qualitative insights from eight co-participants through in-depth interviews. The quantitative results indicated that AI tools were moderately used and perceived as useful, with simulations and visualization applications being the most common. Usage was particularly evident in teaching Light, the Electromagnetic Spectrum, and Electricity and Magnetism. However, the integration of AI tools was largely confined to demonstration and initial engagement phases, with limited application in assessment and evaluation. Statistical analysis revealed a significant negative correlation between frequency of AI tool usage and reported effectiveness, suggesting a gap between technological access and pedagogical alignment. The qualitative findings highlighted challenges such as insufficient training, unreliable infrastructure, resource limitations, and concerns over content reliability and ethical implications. Despite these constraints, teachers expressed a strong intent to continue adopting AI tools, motivated by their observed potential to increase student engagement. The study proposes the AI-SCI program, designed to enhance teacher competence, strengthen infrastructure, and ensure ethical integration, thereby supporting more effective AI adoption in Philippine science education.

Keywords: Artificial Intelligence, Inquiry-Based Learning, Physics Instruction, Secondary Education, Teacher Integration

INTRODUCTION

The rapid advancement of digital technologies has transformed educational practices worldwide, with artificial intelligence (AI) emerging as one of the most influential tools in reshaping teaching and learning. In recent years, AI has increasingly been applied in education to provide adaptive learning systems, intelligent tutoring, automated assessments, and personalized instructional feedback. These applications are designed to meet the diverse needs of learners while supporting teachers in creating moreinteractive and engaging learning environments. Scholars emphasize that AI can serve as a catalyst for innovation in science education, especially in contexts where traditional instructional methods have struggled to address learners' varying cognitive levels and access to resources (Wangdi, 2024; Li, 2024).

Within the domain of science, inquiry-based learning has been widely regarded as an effective approach for cultivating critical thinking, problem- solving, and scientific reasoning among students. The method emphasizes exploration, questioning, and discovery, enabling learners to construct knowledge actively rather than passively receiving information. The integration of AI with inquiry-based learning offers a synergistic effect: AI technologies facilitate simulations, adaptive questioning, and real-time data analysis, while inquiry-based strategies provide the structure for meaningful exploration and knowledge construction (Aisyah, 2023;Putri et al., 2024). This integration addresses long-standing challenges in science instruction, such as students' difficulties in visualizing abstract concepts and teachers' limited capacity to provide individualized feedback in large classrooms.

Globally, studies reveal that inquiry-based approaches supported by AI tools lead to measurable improvements in student learning outcomes. For instance, guided inquiry models combined with digital platforms have been shown to significantly enhance science process skills and conceptual understanding (Mursali et al., 2024). Similarly, experimental evidence indicates that AI-supported inquiry instruction fosters scientific literacy and encourages student engagement across different grade levels (Faizin et al., 2024). These findings underscore the potential of AI-enhanced inquiry instruction to transform science education into a more student-centered, interactive, and outcome-oriented practice.

In the Philippines, the integration of educational technologies has gained momentum, particularly in response to the learning disruptions caused by the COVID-19 pandemic. Teachers have begun to explore generative AI tools such as Microsoft Bing Chat and Canva, which enhance lesson design and classroom engagement (Arguson et al., 2023). However, while these technologies are increasingly embraced, systemic issues—such as inadequate infrastructure, lack of teacher training, and data privacy concerns—limit their meaningful adoption (Estrellado & Miranda, 2023). These challenges are magnified in rural and provincial contexts where disparities in access to devices, connectivity, and institutional support remain stark. Thus, the Philippine educational system faces the dual task of maximizing the pedagogical benefits of AI while addressing structural inequities that hinder its implementation.

Within this context, the teaching of Grade 10 Physics presents unique challenges. Physics concepts, particularly in areas such as Light, the Electromagnetic Spectrum, and Electricity and Magnetism, are inherently abstract and often difficult for students to conceptualize through traditional methods. Inquiry-based instruction provides a pathway for students to engage with these concepts experientially. Yet, despite its potential, there is limited evidence on how AI tools are being integrated into this pedagogical framework in Philippine public secondary schools. Although international studies provide insights into AI-supported inquiry models, there is a pressing need for localized research to examine how such practices unfold in specific educational settings, including the Schools Division Office (SDO) of Quezon Province.

The research gap lies in the insufficient understanding of both the extent and effectiveness of AI integration in inquiry-based Physics instruction within Philippine public schools. Existing studies have primarily documented either the broad applications of AI in education or the general benefits of inquiry-based learning (Orosz et al., 2022; Hamid et al., 2023). Few have explored the intersection of these two domains in local contexts, particularly focusing on subject-specific applications such as Physics. Moreover, while AI's potential for personalization and real- time feedback is widely acknowledged, empirical studies often overlook the challenges teachers face in aligning these tools with inquiry-based methods. Issues such as limited professional preparation, lack of institutional support, and concerns about AI's reliability and ethical implication remain underexplored in Philippine settings (Ni et al., 2023; D'Souza, 2024).

Addressing this gap is crucial because the integration of AI in Physics instruction has implications not only for improving student learning outcomes but also for building teacher competence in technology-enhanced pedagogies. Furthermore, it contributes to the Department of Education's broader goals of advancing STEM education and preparing learners for participation in a technology-driven global economy. By investigating how AI tools are currently used in inquiry-based Physics instruction, this study seeks to generate evidence that can inform teacher training programs, policy frameworks, and school-level initiatives aimed at optimizing digital integration.

The rationale for this study rests on three interrelated considerations. First, the pedagogical promise of AI-enhanced inquiry learning must be validated within real-world classroom contexts, particularly in public schools that often face systemic limitations. Second, the study provides empirical grounding for policy directions in the Department of Education's digital transformation agenda. And third, it aims to empower teachers by documenting not only their successes but also the barriers they encounter in implementing AI in inquiry-based instruction. These insights are expected to contribute to the design of context- sensitive action programs that address local realities while advancing global trends in educational innovation.

To guide the inquiry, this study articulates specific objectives. It seeks to identify the AI tools most commonly integrated into Grade 10 Physics instruction under the SDO of Quezon Province, to determine the extent of their utilization in terms of usage and perceived usefulness, and to explore the relationship between AI tool adoption and instructional practices. It also aims to document the challenges, concerns, and future intentions of teachers with respect to AI integration. Finally, the study intends to propose an action program—AI-SCI(Advancing Instruction through Smart Classroom Integration for Science Mastery)—that aligns AI applications with inquiry-based pedagogies.

These objectives translate into clear research questions: Which AI tools are commonly integrated into inquiry-based learning for Grade 10 Physics across the content areas of Light, Electromagnetic Spectrum, and Electricity and Magnetism? To what extent are these tools utilized in terms of usage and perceived usefulness? Is there a significant relationship between the AI tools employed and the degree of integration in Physics instruction? What challenges, concerns, and intentions characterize teachers' experiences with AI tool adoption? And, based on these insights, what action program can be developed to support more effective and sustainable integration?

By addressing these questions, the study positions itself at the intersection of technological innovation and pedagogical reform. It responds to global calls for leveraging AI to enhance science education while situating its inquiry within the realities of Philippine public schools. As such, it not only contributes to the literature on AI and inquiry-based instruction but also offers actionable insights for teachers, policymakers, and educational leaders seeking to transform science classrooms into dynamic environments of discovery, equity, and innovation.

METHODOLOGY

This study employed a convergent parallel mixed-methods research design, chosen to provide a comprehensive understanding of the integration of artificial intelligence (AI) tools in inquiry-based Physics instruction for Grade 10 in public secondary schools under the Schools Division Office (SDO) of Quezon Province. The convergent parallel design allowed the researcher to simultaneously collect quantitative and qualitative data, analyze them separately, and then merge the findings to validate and enrich the interpretations. The quantitative component focused on identifying the frequency and extent of AI tool usage, while the qualitative component explored the experiences, challenges, and future intentions of teachers with regard to AI integration. By combining both approaches, the study was able to generate a holistic perspective on how AI tools are employed in classrooms and how teachers perceive their effectiveness in enhancing inquiry- based learning.

The study population consisted of all Grade 10 science teachers across the four congressional districts of the SDO Quezon Province during the 2024–2025 academic year. This population included 682 teachers distributed as follows: 162 from the First District, 140 from the Second District, 165 from the Third District, and 215 from the Fourth District. To obtain a representative sample, Slovin's formula was applied with a five percent margin of error, resulting in a sample size of 252 teachers. Proportional allocation ensured equitable representation across districts, producing 60 respondents from the First District, 52 from the Second District, 61 from the Third District, and 79 from the Fourth District. Beyond the survey respondents, eight additional teachers served as co-participants in the qualitative phase. Two teachers from each district were purposively selected for in-depth interviews, based on their teaching experience and active use of AI tools in Physics instruction. This dual sampling strategy enabled the study to capture both breadth and depth of teacher practices and perceptions.

The primary instrument for the quantitative phase was a researcher- designed survey questionnaire. The instrument was structured into sections that elicited demographic information, identified AI tools commonly used in teaching Physics, and measured the extent of AI integration in terms of usage and perceived usefulness. The survey utilized a Likert-type scale to allow respondents to indicate degrees of frequency and effectiveness in their AI tool usage. To ensure validity, the instrument underwent a multi-step process of evaluation. Drafts were submitted to a panel of validators composed of experts in science education, educational technology, and research methodology. Their feedback guided revisions that improved clarity, alignment with research objectives, and construct validity. Reliability was further established through pilot testing with a small group of science teachers not included in the final sample, after which necessary adjustments were incorporated.

For the qualitative phase, semi- structured interview guides were developed to elicit narratives on teachers' experiences, challenges, and future intentions regarding AI integration in Physics instruction. The interview questions were framed to explore both opportunities and barriers to effective use of AI tools, as well as teachers' reflections on how these technologies might reshape their instructional roles. The semi-structured format provided flexibility, allowing participants to elaborate on personal experiences while ensuring that all relevant themes were covered. Interviews were conducted face-to-face where feasible and online when necessary, depending on participant availability and logistical considerations. Each session was audio- recorded with consent and subsequently transcribed for analysis.

The process of data collection adhered to rigorous procedures to maintain consistency and credibility. Quantitative data were gathered through survey administration distributed directly to the participating schools across the four districts. Coordination with school principals and district supervisors facilitated efficient dissemination and retrieval of questionnaires. The researcher personally oversaw the process to ensure high response rates and address queries from respondents. Simultaneously, qualitative interviews were conducted with the selected co-participants. Each interview lasted approximately 45 to 60 minutes, and participants were assured that they could decline to answer any question they were uncomfortable with. This dual process of collecting survey responses and conducting interviews in parallel aligned with the convergent mixed-methods approach, ensuring that both strands of data reflected the same timeframe and context.

The analysis of quantitative data was performed using descriptive and inferential statistics. Frequency counts and percentages were computed to identify the most commonly used AI tools and to describe their extent of utilization in different Physics content areas. Mean scores were calculated to determine levels of usage and perceived usefulness. To examine relationships between the types of AI tools employed and the extent of integration, Spearman's Rank-Order Correlation was applied, as this non- parametric test was appropriate for ordinal data derived from the Likert scales. Statistical analyses were conducted using SPSS software, and results were carefully interpreted to establish both patterns and associations relevant to the research objectives.

The qualitative data were analyzed using thematic analysis, specifically Braun and Clarke's six-phase framework. This involved familiarization with the transcribed data, initial coding of significant statements, searching for recurring patterns, reviewing themes, defining and naming themes, and finally, producing coherent narrative accounts. A deductive approach guided the coding process, as categories were aligned with the research questions focusing on challenges, concerns, and future intentions. Nonetheless, openness to emergent themes was maintained to capture unexpected insights from participants. Triangulation of qualitative findings with quantitative results strengthened the credibility of interpretations, allowing the study to present convergent and divergent evidence about AI integration in Physics education.

Ethical considerations were integral throughout the research process. Prior to data collection, the researcher sought and obtained approval from the Graduate School of Education of the University of Perpetual Help System DALTA. Official permission was also secured from the Schools Division Superintendent of Quezon Province to conduct the study in public secondary schools. Teachers were invited to participate voluntarily, and informed consent forms were provided outlining the purpose of the study, procedures, potential risks, and assurances of confidentiality. Participants were informed that they could withdraw from the study at any time without penalty. To ensure data privacy, the study complied with the provisions of the Data Privacy Act of 2012 and the National Privacy Commission's Circular No. 2023-04. Collected data were anonymized, stored securely, and used exclusively for academic purposes.

The methodological rigor of this study lay in its careful design and adherence to ethical standards. The convergent parallel mixed-methods design allowed the simultaneous collection and comparison of quantitative and qualitative evidence, ensuring that the findings reflected both general trends and individual teacher perspectives. The use of validated instruments, systematic data collection procedures, and robust analytical techniques further strengthened the reliability and validity of the results. By foregrounding ethical safeguards and institutional approvals, the research ensured respect for participants and compliance with national regulations.

Through these methodological procedures, the study sought to generate credible, replicable, and contextually grounded insights into the integration of AI tools in inquiry-based Physics instruction in Quezon Province. The design and execution of the methodology provided a strong foundation for analyzing the effectiveness, challenges, a n d futuredirections of AI adoption in Philippine science education.

RESULTS

The purpose of this study was to examine the integration of artificial intelligence tools in inquiry-based Physics instruction for Grade 10 in public secondary schools of Quezon Province. The results are presented in line with the research questions, beginning with the AI tools most commonly used by teachers, followed by the extent of utilization, the statistical relationship between usage and content areas, the challenges and concerns expressed by teachers, and the future intentions that emerged from the qualitative phase.

The first research question sought to identify the artificial intelligence tools most commonly integrated into inquiry-based Physics instruction across the three content areas of Light, Electromagnetic Spectrum, and Electricity and Magnetism. Quantitative data from the 252 teacher respondents revealed that in the area of Light, simulation platforms such as PhET Interactive Simulations and AI-powered visualization applications were most frequently cited. Of the respondents, 71 percent reported using simulations in lessons on reflection and refraction, while 65 percent indicated employing AI-assisted digital animations to demonstrate optical phenomena. In the Electromagnetic Spectrum, 62 percent of teachers used AI-driven digital laboratories to illustrate wave properties, and 58 percent utilized AI content creation tools such as Canva with embedded AI features to design learning materials. For Electricity and Magnetism, 68 percent of respondents indicated reliance on AI-powered problem generators to provide practice questions on Ohm's Law and circuit analysis, while 61 percent used adaptive platforms that adjust question difficulty in real time. These findings indicate that while teachers made use of a range of AI tools across content areas, the heaviest reliance was placed on simulation-based applications.

The second research question addressed the extent of utilization of AI tools in terms of usage and perceived usefulness. Results indicated that teachers reported a moderately high level of integration. For usage, the composite mean score was 3.21 on a four-point scale, suggesting that most respondents employed AI tools frequently during instruction. With respect to perceived usefulness, the mean score was 3.34, indicating that teachers generally found AI tools effective in aiding student understanding. Across content areas, Light registered the highest perceived usefulness with a mean of 3.42, followed by Electricity and Magnetism at 3.31, and the Electromagnetic Spectrum at 3.28. Teachers explained that AI simulations in the topic of Light provided "a clearer way for students to visualize what is otherwise invisible to the naked eye," while one teacher from District Two noted, "When I show an AI-powered ray diagram simulation, the students immediately understand reflection and refraction compared to when I draw it manually on the board."

Despite these reported levels of usage, teachers indicated that the application of AI tools was often limited to introductory demonstrations or supplementary engagement activities. This pattern was evident in the frequency distributions, which showedthat only 43 percent of respondents reported using AI consistently for assessment purposes, and only 38 percent indicated that they used adaptive learning platforms throughout the lesson cycle. Teachers appeared to be more comfortable employing AI during the Engage and Explore stages of the 5E model rather than during evaluation or deeper elaboration.

The third research question sought to determine whether there was a significant relationship between the AI tools used in different content areas and the extent of their utilization. Statistical analysis using Spearman's Rank-Order Correlation revealed a negative correlation between AI tool usage and learning outcomes, with coefficients ranging from –0.21 to –0.29 across the three content areas, all significant at the

0.05 level. This finding suggests that higher reported usage of AI tools did not correspond with higher perceived instructional effectiveness. Instead, teachers who frequently used AI tools tended to report moderate levels of effectiveness, pointing to a possible misalignment between the tools and the intended learning objectives. For example, in the Electromagnetic Spectrum, where 62 percent reported high AI tool usage, the correlation coefficient was –0.27, reflecting the discrepancy between frequency of use and effectiveness.

The fourth research question focused on the challenges, concerns, and future intentions of teachers in integrating AI tools. Qualitative interviews with eight co-participants revealed recurring themes that highlighted both systemic and pedagogical barriers. The first emergent theme was inadequate training.

Teachers repeatedly emphasized the lack of professional development opportunities to equip them with the necessary skills to maximize AI tools. One teacher stated, "I only know how to use the basic features of the simulations. Nobody has trained us on how to integrate them into full lesson plans." Another teacher added, "AI is powerful, but without proper training, we are just scratching the surface."

A second theme concerned digital infrastructure and resource limitations. Several participants described unreliable internet connections, insufficient devices, and lack of school funding as significant obstacles. A respondent from District Four remarked, "Sometimes the AI simulation does not load at all because our internet is too weak. We are forced to revert to traditional teaching methods." Another noted, "Only two computers are available in our laboratory, so most students cannot actually interact with the AI tools. They just watch me demonstrate."

The third theme revolved around content reliability and ethical concerns. Teachers expressed caution regarding the accuracy of AI-generated content and the implications of using AI in assessments. One teacher explained, "Some AI problem sets provide incorrect solutions, and this confuses the students. I have to double-check everything before presenting." Another reflected, "AI can give quick answers, but it might encourage students to rely on shortcuts instead of critical thinking." Data privacy was also a recurrent concern, with one participant stating, "We are required to protect student information, but some AI platforms ask us to input details, which makes me uncomfortable."

Despite these challenges, the fourth theme highlighted strong intent to continue AI integration. Teachers conveyed optimism that with the right support, AI tools could transform Physics instruction. A teacher from District One explained, "If we are given proper training and resources, I believe AI can make Physics much more engaging for students." Another participant emphasized, "I want to continue exploring AI because students are excited whenever we use it. Their motivation increases, and that is already a big step in learning."

The final research question aimed to identify the basis for developing an action program to support AI integration. Quantitative and qualitative results converged to show that while teachers widely used AI tools for engagement and demonstration, deeper integration into inquiry cycles remained limited. The findings suggested that professional development, infrastructure improvements, and alignment with inquiry-based pedagogy were essential for effective implementation. The proposed action program, AI-SCI (Advancing Instruction through Smart Classroom Integration for Science Mastery), was grounded in these insights. The program focused on equipping teachers with training on AI-enhanced inquiry strategies, strengthening digital infrastructure in schools, and ensuring that AI tools were ethically and pedagogically sound.

Across the dataset, it became clear that teachers in Quezon Province embraced AI tools with a positive outlook but encountered tangible barriers that restricted their potential. Quantitative data demonstrated moderately high usage and perceived usefulness, while statistical analysis highlighted inconsistencies between frequency of use and learning outcomes. The qualitative findings added depth by revealing how lack of training, weak infrastructure, and reliability issues shaped teachers' experiences. Importantly, the voices of the participants conveyed both the frustration of limited resources and the enthusiasm for future possibilities. As one teacher summarized, "AI is not yet perfect for our classrooms, but it gives us a glimpse of what science education could become if we are prepared to use it properly."

DISCUSSION

The findings of this study underscore both the promise and complexity of integrating artificial intelligence tools into inquiry-based Physics instruction in Philippine public secondary schools. The quantitative results revealed moderately high levels of usage and perceived usefulness, yet these were accompanied by a negative correlation between frequency of tool usage and instructional outcomes. Meanwhile, the qualitative data illuminated challenges of inadequate training, weak infrastructure, and concerns about reliability, while simultaneously pointing to teachers' optimism and intent to deepen AI integration. When contextualized within existing scholarship, these results reveal important theoretical contributions, practical implications, and limitations for advancing the effective adoption of AI in science education.

The identification of simulations and visualization platforms as the most commonly used AI tools in Physics reflects global patterns in educational technology adoption. Previous research has highlighted the effectiveness of simulations in supporting abstract science concepts, particularly in areas like optics and electromagnetism (Putri et al., 2024). Teachers in this study echoed these findings, noting that AI- driven visualizations made phenomena such as reflection, refraction, and wave behavior more accessible to learners. This aligns with constructivist perspectives that emphasize active exploration and visualization as central to knowledge construction (Karlina et al., 2024). However, the heavy reliance on simulations primarily during the Engage and Explore phases of the 5E instructional model suggests that teachers have not yet fully capitalized on AI tools for deeper stages of inquiry, such as elaboration or evaluation. This partial integration may explain the observed mismatch between frequency of use and effectiveness, underscoring the need for professional development focused on aligning AI resources with the full inquiry cycle.

The negative correlation between AI tool usage and perceived effectiveness provides a striking counterpoint to much of the literature that has celebrated AI's capacity to enhance learning outcomes. While studies in higher education and technologically advanced contexts have demonstrated that AI-powered adaptive systems improve student performance and engagement (Deshpande et al., 2024; Wills, 2024), the present results suggest that in resource-constrained environments, increased reliance on AI does not automatically translate into better outcomes. Rather, frequent use without sufficient alignment to pedagogical goals may result in superficial applications that fail to deepen conceptual understanding. This pattern resonates with findings by Li (2024), who warned that overreliance on AI without careful pedagogical framing risks diminishing critical thinking and fostering dependence on automated outputs. The results from Quezon Province therefore highlight the necessity of not only providing access to AI tools but also cultivating the pedagogical expertise required to integrate them meaningfully into inquiry-based instruction.

The challenges identified by teachers illuminate systemic barriers that mirror concerns raised in broader educational contexts. The lack of training emerged as the most significant constraint, with teachers openly acknowledging that their current knowledge of AI tools remained limited to surface-level features. This finding is consistent with Wangdi (2024), who argued that effective AI integration requires professional development programs that equip teachers with both technical and pedagogical competencies. Similarly, studies in the Philippine context have underscored that without sustained capacity-building, teachers may embrace new technologies with enthusiasm but fail to embed them deeply in instruction (Estrellado & Miranda, 2023). The testimonies of participants in this study, such as "Nobody has trained us on how to integrate them into full lesson plans," demonstrate the gap between access to tools and the know-how to maximize their potential.

Infrastructure constraints represent another layer of difficulty, particularly in rural and provincial schools. Teachers' accounts of weak internet connectivity and limited devices reflect the broader digital divide in Philippine education, where disparities in access continue to hinder equitable technology adoption (Cajurao et al., 2023). This structural limitation curtails the scalability of AI integration, as even the most motivated teachers cannot implement AI-enhanced strategies without stable infrastructure. International research has also noted that unequal access to digital tools risks exacerbating educational inequalities rather than reducing them (Tilepbergenovna, 2024). Within the local context of Quezon Province, this means that while AI holds transformative potential, its benefits remain contingent on investments in digital infrastructure that extend beyond individual classrooms.

Concerns over the reliability and ethical implications of AI further complicate its adoption. Teachers' experiences with inaccurate AI- generated problem sets reflect what D'Souza (2024) identified as the problem of algorithmic bias and error, which can undermine the credibility of AI tools in educational settings. Moreover, apprehensions regarding student overreliance on AI for quick answers connect to the warning raised by Ni et al. (2023) that AI poses risks to academic integrity and critical thinking. Ethical issues, particularly around data privacy, were also raised by participants, with some noting discomfort over inputting student information into AI platforms. This is particularly salient in the Philippines, where the Data Privacy Act of 2012 and the National

Privacy Commission's Circular No. 2023-04 mandate strict safeguards for personal data. The findings suggest that any strategy for scaling AI in education must integrate clear ethical guidelines and mechanisms to protect both teachers and students.

Despite these barriers, the optimism expressed by teachers represents a crucial finding with significant implications. Teachers consistently reported a desire to continue experimenting with AI tools, citing observable increases in student engagement. This aligns with Bit et al. (2024), who emphasized that even amid skepticism and challenges, AI adoption persists because of its ability to motivate learners. The teachers' positive outlook reflects resilience and openness to innovation, suggesting that with the right support, educators in resource-constrained contexts can be powerful agents of technological transformation. Their willingness to persist despite obstacles echoes Vygotskian notions of scaffolding, wherein motivated learners—in this case, teachers—advance when provided with sufficient guidance and resources (Vygotsky, as cited in Orosz et al., 2022).

Theoretically, the findings of this study contribute to the ongoing discourse on constructivist and inquiry- based frameworks in the era of artificial intelligence. By documenting how AI tools are used to scaffold the learning of abstract Physics concepts, the study illustrates how Piagetian constructivism and Deweyan inquiry intersect with modern technologies. At the same time, the results highlight that without deliberate integration across all phases of inquiry, the transformative potential of AI remains underrealized. This adds nuance to the Connectivist perspective articulated by Siemens, which emphasizes the role of digital networks in expanding access to knowledge (Siemens, as referenced in Kujundziski & Bojadjiev, 2024). In practice, teachers in Quezon Province connected to AI networks but did not yet maximize these resources to foster higher-order inquiry. Thus, the study suggests that theoretical frameworks must be revisited to account for the contextual realities of educators who are navigating both opportunities and constraints in AI adoption.

Practically, the study offers important insights for stakeholders at multiple levels. For teachers, the findings provide benchmarks for reflecting on their own use of AI tools and highlight areas where further training is needed. For school leaders and subject coordinators, the data underscore the necessity of professional development programs that move beyond tool orientation to pedagogy-centered integration. For policymakers in the Department of Education, the results provide empirical evidence supporting the need to prioritize digital infrastructure investments, particularly in provincial contexts. The proposed action program, AI-SCI, addresses these practical dimensions by recommending structured training, infrastructure support, and alignment of AI tools with inquiry-based pedagogies. Such a program, if implemented, could position Quezon Province as a model for other regions seeking to integrate AI in science education responsibly and effectively.

At the same time, the study is not without limitations. The reliance on self- reported data from teachers introduces the possibility of response bias, as participants may have overestimated their use or effectiveness of AI tools. While the sample size was robust, the study was confined to Grade 10 Physics teachers in one province, limiting the generalizability of findings to other grade levels, subjects, or regions. Moreover, the negative correlations observed highlight complexities that cannot be fully explained through quantitative measures alone. Although qualitative insights shed light on some of these complexities, further longitudinal research is needed to explore the evolving relationship between AI use and learning outcomes.

In reflecting on these findings, it becomes evident that the integration of AI into inquiry-based Physics instruction is neither a straightforward process nor an unqualified success. Rather, it is a dynamic and evolving practice shaped by the interplay of teacher capacity, institutional infrastructure, ethical considerations, and student needs. The results from Quezon Province contribute to the growing body of evidence that while AI can enrich science education, its impact depends on how it is contextualized, supported, and aligned with pedagogical frameworks. As such, the study reinforces the argument advanced by Elmourabit et al. (2024) that generative and adaptive AI must be harnessed thoughtfully, with an emphasis on empowering both teachers and learners.

CONCLUSION

The study investigated the integration of artificial intelligence tools in inquiry-based Physics instruction among Grade 10 teachers in public secondary schools of Quezon Province. Through a convergent parallel mixed-methods design, it documented the extent of AI tool usage, the perceived usefulness of these resources, the relationship between frequency of use and instructional effectiveness, and the challenges and intentions of teachers in adopting AI in their classrooms. Findings revealed that teachers reported moderately high levels of both usage and usefulness, with simulations and visualization applications most frequently employed in teaching abstract concepts such as Light, the Electromagnetic Spectrum, and Electricity and Magnetism. Yet, while AI tools were actively incorporated during the engagement and exploration stages of instruction, their integration into assessment and evaluation phases remained limited.

Statistical analysis further indicated a negative correlation between frequent AI use and reported instructional outcomes, suggesting that high levels of usage did not necessarily align with improved effectiveness. This pattern reflected the reality that without appropriate training and alignment to pedagogical frameworks, AI applications often remained superficial, confined to demonstration rather than deeper inquiry. The qualitative findings reinforced this perspective by revealing systemic barriers such as inadequate teacher preparation, unreliable digital infrastructure, limited resources, and concerns about content reliability and ethical implications. Despite these obstacles, teachers expressed strong intent to continue experimenting with AI tools, particularly because of their observed potential to enhance student motivation and engagement.

The significance of these findings lies in the insights they provide into how technology adoption unfolds in resource-constrained educational contexts. Teachers in Quezon Province demonstrated openness to innovation and a willingness to adapt their practice, but their efforts were hindered by conditions beyond individual control. The study highlights the critical role of institutional support, policy direction, and infrastructure investment in ensuring that AI integration does not exacerbate inequalities but instead empowers both teachers and students to benefit from its transformative potential.

Based on the results, several recommendations emerge. For classroom practice, there is a need to strengthen teacher professional development not only on the technical use of AI platforms but also on strategies to align these tools with inquiry-based pedagogy. For school administrators and subject coordinators, targeted initiatives that provide access to reliable devices, improve connectivity, and encourage collaborative sharing of best practices can foster a more enabling environment for AI adoption. At the policy level, the Department of Education may consider crafting guidelines that integrate AI into broader digital transformation goals while ensuring compliance with ethical standards and data privacy regulations. For future research, further studies could extend beyond Physics and Quezon Province to other subjects, grade levels, and regions to provide a broader understanding of AI integration in Philippine education. Longitudinal investigations may also be undertaken to examine how teachers' expertise and student learning outcomes evolve as exposure to AI tools becomes more sustained.

Through these findings and recommendations, the study contributes to ongoing efforts to advance science education in the Philippines. It emphasizes that while artificial intelligence presents exciting opportunities for inquiry-based learning, its impact depends on how effectively it is aligned with pedagogical frameworks, supported by infrastructure, and contextualized within the realities of public-school settings. By addressing gaps in training, resources, and ethical safeguards, stakeholders can ensure that AI serves as a catalyst for deeper engagement, meaningful learning, and equitable access to quality education.

Output of the Study

The findings of this research culminated in the development of an action program entitled AI-SCI (Advancing Instruction through Smart Classroom Integration for Science Mastery). This program was designed to support the meaningful integration of artificial intelligence tools into inquiry- based Physics instruction for Grade 10 in public secondary schools of Quezon Province. Grounded in both quantitative data from 252 teacher-respondents and qualitative insights from eight co- participants, AI-SCI responds to the opportunities and challenges identified in the study while providing a structured and sustainable pathway for improving science education.

At the core of AI-SCI is the enhancement of teacher competence through sustained professional development. The study revealed that many teachers were able to access AI platforms such as simulations and adaptive problem sets but lacked training on how to embed these resources across the full inquiry cycle. To address this gap, AI-SCI prioritizes capacity-building initiatives that integrate both technical training and pedagogy-centered workshops. Teachers are equipped not only with knowledge of how AI tools function but also with strategies for aligning these tools with the 5E instructional model and the Most Essential Learning Competencies. Through these initiatives, the program aims to move AI integration beyond basic demonstration toward more meaningful applications that foster inquiry, problem-solving, and critical reasoning.

The program also emphasizes curriculum alignment to ensure that AI tools are systematically embedded into Physics instruction. The study's findings indicated that AI was often used primarily during the initial phases of lessons, limiting its potential to support higher-order inquiry. AI-SCI addresses this by providing guidelines for curriculum mapping that weave AI- enhanced tasks into various stages of instruction, from engagement to evaluation. This alignment ensures that technology is not treated as an optional supplement but as a tool that reinforces both conceptual mastery and the development of scientific skills.

Institutional support forms another critical component of AI-SCI. Teachers highlighted persistent challenges related to limited digital infrastructure, unreliable internet access, and insufficient devices. Recognizing that these issues extend beyond the control of individual educators, the program underscores the role of school leaders, division ICT coordinators, and local planners in ensuring equitable resource distribution. It encourages the prioritization of infrastructure improvements and the establishment of partnerships with local government units and educational agencies. By addressing these structural barriers, AI- SCI ensures that teachers can effectively implement the strategies they are trained to use.

Alongside infrastructure and training, AI-SCI integrates clear policies and ethical safeguards. Teachers in the study expressed concern about the reliability of AI-generated content, the risk of student overreliance, and compliance with existing data privacy regulations. In response, the program recommends the development of protocols for verifying AI-based instructional materials, strategies to minimize overdependence, and strict adherence to the Data Privacy Act of 2012 and the National Privacy Commission's Circular No. 2023-04. By embedding these ethical considerations, AI-SCI ensures that the use of AI tools supports academic integrity and learner safety while protecting the irreplaceable role of teachers in facilitating inquiry.

Sustainability and scalability are also central to the AI-SCI framework. The program advocates for ongoing monitoring and evaluation to measure the impact of AI integration on teacher practices and student learning. Feedback loops are incorporated to allow for iterative adjustments based on classroom realities. Additionally, AI-SCI is designed with scalability in mind, so that once it has been piloted successfully in Grade 10 Physics, it can be expanded to other grade levels and science subjects. This adaptability ensures that the program remains relevant to the evolving needs of schools and learners.

Ultimately, the AI-SCI program represents the practical output of this study, rooted in evidence and responsive to both numerical data and the lived experiences of teachers. By bringing together professional development, curriculum integration, institutional support, ethical safeguards, and sustainability mechanisms, the program provides a comprehensive framework for advancing science instruction. It aspires to empower teachers, engage students, and equip schools with the capacity to integrate AI in ways that are innovative, ethical, and transformative. Through AI-SCI, Physics education in Quezon Province can evolve into a model of technology-enhanced, inquiry-driven learning that prepares students for a rapidly changing world.

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Ethical Approval Statement

This study received ethical clearance from the Graduate School of Education, University of Perpetual Help System DALTA, Las Piñas City. Approval was granted prior to data collection in compliance with the Data Privacy Act of 2012 and NPC Circular No. 2023-04. All involved institutions issued formal permission to conduct the study, and informed consent, confidentiality, and voluntary participation were strictly upheld.

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AUTHOR BIO

Windel Raposas Nogot is a licensed professional teacher and currently a public- school STEM educator and mentor at Sto. Domingo National High School, Quezon Province, Philippines. He is pursuing his Doctor of Philosophy in Education major in Science Education at the University of Perpetual Help System DALTA, Las Piñas City. A Google Certified Educator, he integrates technology into teaching to foster creativity, collaboration, and inclusive learning. He also holds a Master of Arts in Education major in Teaching Science and a Bachelor of Secondary Education major in Physical Science. His interests include mentoring, networking, and educational innovation.