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Teachers' Perceptions on the Integration of EdTech Tools in Science Education: Implementation, Benefits, and Challenges

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ABSTRACT

This study examined the implementation, perceived benefits, and challenges of integrating educational technology (EdTech) tools into science instruction in selected private high schools in Pandi North and South, Bulacan, Philippines. Anchored in the Technology Acceptance Model, it employed a convergent parallel mixed-methods design combining a descriptive-comparative survey and phenomenological interviews. The quantitative strand involved 32 respondents, comprising 23 science teachers and nine administrators, while nine purposively selected participants contributed to the qualitative strand. A validated researcher-developed questionnaire demonstrated internal consistency (Cronbach's alpha = 0.898). Quantitative findings were summarized using percentages and weighted means, while interview data underwent thematic analysis. AI-powered tutors were reported by 78.1% of respondents and PhET Interactive Simulations by 21.9%. Implementation was moderate in planning (3.20), instruction (2.55), and intervention and assessment (3.03). Respondents agreed that EdTech supported engagement (3.44) and achievement (3.49), and strongly agreed regarding collaboration (3.51). Reported comparison results indicated significant differences in planning and instruction by school location and in planning by tool type, whereas perceived benefits showed no significant group differences. Qualitative findings identified connectivity constraints, unequal device access, professional development gaps, student hesitation and AI dependence, and adaptive teaching strategies. Integrated findings highlighted the need for equitable access, pedagogical support, and responsible technology use. Seven proposed guidelines address these priorities through instructional practices, professional development, infrastructure improvement, and monitoring. The findings provide context-specific evidence for strengthening science instruction, although perceived benefits should not be interpreted as directly measured student learning outcomes or causal effects.

Keywords: *educational technology, science instruction, technology acceptance, mixed methods, artificial intelligence, teacher perceptions, digital equity*

INTRODUCTION

In recent years, the integration of educational technology (EdTech) tools in science instruction has gained momentum, providing innovative ways to enhance teaching and learning. Platforms such as ChatGPT, Gemini, Copilot, Quillbot, Gamma AI, and Canva AI are increasingly being utilized for content creation and lesson planning. Meanwhile, interactive tools like PhET Simulations, Google Expeditions, and VR glasses offer immersive experiences that can deepen students' understanding of scientific concepts.

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When effectively implemented, educational technology can enhance learning by improving accessibility and engagement. In the Philippines, however, disparities in infrastructure and resource availability continue to hinder its full integration, particularly in schools and underserved communities (Espinosa et al., 2023).

Notably, over 80% of all basic education levels have functional computers for teaching and administration as of SY 2020-2021 (Philippine News Agency, 2022). The use of technology has democratized access to online platforms and EdTech tools especially for students and teachers in remote areas which help in enhancing students' engagement and become an effective tool for knowledge creation as well as for attainment of integrated, constructive teaching-learning environments (Radianti et al., 2020; Prasad et al., 2024).

As schools adapt to the growing presence of technology, science teachers play a crucial role in implementing these tools effectively. However, while these technologies present numerous opportunities in science instruction, they also pose challenges that affect teachers' instructional practices and classroom management. Several studies conducted noted that despite the increasing adoption of EdTech tools, there remains a lack of research that focuses on science teachers' perceptions of both the advantages and difficulties they encounter in integrating these technologies. Existing studies often emphasize student outcomes rather than the teachers' experiences, needs, and challenges (Tamang et al., 2021; Cahapay, 2021; Trinidad & Leviste, 2021; & Bacolod, 2022).

This study aimed to fill this gap by providing a teacher-centered approach on the use of EdTech tools in science instruction. By focusing on how these tools were used by teacher in their classrooms, the study could provide practical insights to support the integration. Moreover, the findings of the study were essential in designing a proposed guidelines to enhance EdTech integration tools in science instruction.

Furthermore, the study was conducted in SDO Bulacan Province within the Districts of Pandi North and South, where various EdTech tools have been integrated into science instruction in the post-pandemic period. The locale provides a relevant context for examining science teachers' perceptions regarding the extent of implementation, perceived benefits, and experiences in using EdTech tools, particularly ChatGPT, Gemini, Copilot, QuillBot, Gamma AI, Canva AI, and PhET Simulations.

Specifically, this study sought to determine the extent of implementation and the extent of perceived benefits of using EdTech tools in science instruction in terms of student engagement, achievement, and collaboration. It also examined whether there were significant differences in the extent of implementation when the respondents were grouped according to their demographic profiles. The findings and conclusions of the study served as the basis for the development of proposed guidelines to enhance the integration of EdTech tools in science instruction.

Theoretical Lens

This study was anchored on the Technology Acceptance Model (TAM) developed by Davis (1989), which provided a theoretical basis for understanding teachers' acceptance and utilization of educational technologies. TAM explains that users' adoption of technology is influenced by two major factors: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Perceived Usefulness refers to the extent to which users believe that a technology improves their performance, while Perceived Ease of Use refers to the extent to which users perceive that a technology can be utilized with minimal effort.

The model suggests that these perceptions influence users' attitudes toward technology, behavioral intentions, and actual technology use. When users perceive a technology as beneficial and manageable, they are more likely to integrate it into their professional practices and sustain its utilization (Davis, 1989; Davis, 1993). Recent information systems research has likewise emphasized the importance of users' perceptions and experiences in determining the acceptance and successful implementation of technological innovations (Marikyan & Papagiannidis, 2024).

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In the context of this study, TAM served as a lens in examining science teachers' perceptions regarding the integration of Educational Technology (EdTech) tools in science education. The concept of Perceived Usefulness was reflected in the perceived benefits of EdTech tools in terms of student engagement, academic achievement, and collaboration. Science teachers who recognized the value of EdTech tools in enhancing instructional practices and supporting student learning were more likely to integrate these technologies into their classroom activities.

Furthermore, Perceived Ease of Use provided a basis for understanding teachers' experiences and challenges in implementing EdTech tools. Factors related to accessibility, usability, technological competence, and the practicality of integrating digital tools influenced teachers' ability to utilize technologies during lesson planning, instruction, intervention, and assessment.

Through the application of TAM, this study examined the extent of EdTech tool implementation among science teachers, the perceived benefits of technology integration, and the significant experiences encountered during the use of EdTech tools. The findings provided insights that served as a basis for developing guidelines to enhance the integration of educational technologies in science education.

Research Paradigm

In this study, a convergent parallel mixed method design was utilized in which the researcher gathered both quantitative and qualitative data concurrently which then the two sets of data were analyzed separately. A triangulation of the findings was done after to provide a more comprehensive understanding of the research problem. This method design allowed the researcher to utilize the quantitative components to provide strong evidence while the qualitative part offers an alternative lens into participants' experiences, perceptions, and challenges. Bringing forth these findings can strengthen the interpretation of the study and reveal perspectives that cannot be shown by using a single method alone (Creswell and Plano Clark, 2018).

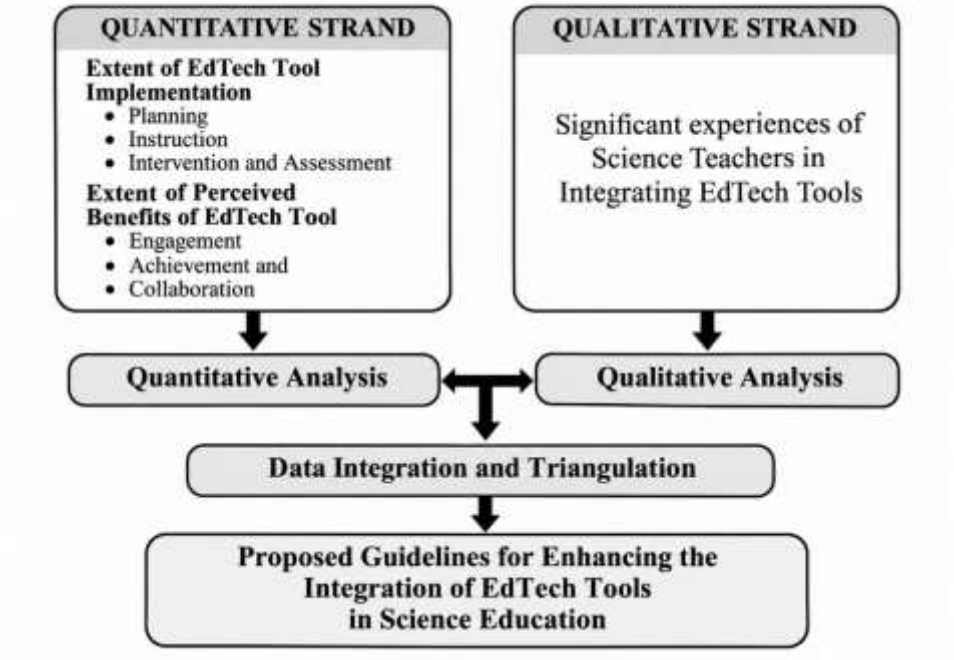

Figure 1. Research paradigm of the study

Figure 1 illustrated the convergent parallel mixed methods research paradigm utilized in the study. In the quantitative approach, the extent of EdTech tool implementation in science classes in terms of

planning, instruction, and intervention and assessment was determined. It also assessed the extent of perceived benefits of EdTech tools with respect to engagement, achievement, and collaboration. The quantitative data were analyzed using appropriate statistical treatments to generate objective and measurable findings regarding EdTech integration. Statistical analyses were performed to determine whether significant differences existed in the extent of implementation and perceived benefits when respondents were grouped according to their demographic profiles. The qualitative approach explored the significant experiences of science teachers in integrating EdTech tools in their teaching practices. Qualitative data were collected and analyzed to identify emerging themes that provided deeper insights into teachers' experiences, perceptions, challenges, and effective practices related to the use of educational technology in science education.

The paradigm showed how the quantitative and qualitative strands were conducted concurrently, analyzed independently, and subsequently integrated to develop evidence-based guidelines for enhancing the integration of EdTech tools in science education. Following the separate analyses of both strands, the findings were brought together through data integration and triangulation. This process involved comparing, relating, and synthesizing the quantitative and qualitative results to obtain a more comprehensive understanding of EdTech tool integration in science education. The integration of findings enabled the strengths of one method to complement the limitations of the other, thereby enhancing the validity and depth of the study's conclusions.

The integrated findings then served as the basis for the development of the study's final output, namely the Proposed Guidelines for Enhancing the Integration of EdTech Tools in Science Education. These guidelines were intended to provide practical recommendations for improving the planning, implementation, and effective utilization of EdTech tools in science classrooms.

Research Objectives

1. Describe school location, school size, and EdTech tools used.
2. Determine the extent of implementation in planning, instruction, and intervention and assessment.
3. Determine perceived benefits in engagement, achievement, and collaboration.
4. Examine differences in implementation by school location, size, and tool type.
5. Examine differences in perceived benefits across these groups.
6. Explore significant experiences in integrating EdTech tools.
7. Develop proposed guidelines for enhancing EdTech integration.

METHODS

Research Design

This study utilized a mixed-method research design, specifically a convergent parallel design, to examine teachers' perceptions on the integration of Educational Technology (EdTech) tools in science education in terms of extent of implementation, extent of teachers' perceived benefits, and challenges. Quantitative and qualitative strands were collected concurrently and analyzed separately before integration (Creswell & Plano Clark, 2018).

This study employed a descriptive-comparative research design to examine teachers' perceptions of the integration of EdTech tools in science instruction. The descriptive component determined the extent of EdTech tool implementation and teachers' perceived benefits in terms of engagement, achievement, and collaboration. The comparative component determined whether significant differences existed in these measures when respondents were grouped according to their demographic profiles. This design was appropriate because the study examined existing practices and perceptions without manipulating any variables or introducing an intervention.

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The qualitative component utilized a phenomenological approach to explore the significant experiences of science teachers in integrating EdTech tools in their classroom practices. Through the qualitative inquiry, the study identified teachers' experiences, encountered challenges, and strategies employed in using educational technologies to support science instruction.

The quantitative and qualitative data were collected concurrently, analyzed separately, and then merged during the interpretation stage. The integration of findings provided a deeper understanding of how science teachers implemented EdTech tools, the benefits they perceived, and the challenges they experienced. The results served as the basis for developing proposed guidelines to enhance the integration of EdTech tools in science education.

Population and Sampling Technique

The participants in the quantitative phase consisted of 32 respondents from the Schools Division of Bulacan, particularly from the Pandi North and South Districts. These included 23 science teachers and nine school administrators who were actively involved in integrating EdTech tools into science instruction. Purposive sampling was employed to select respondents with direct experience in using EdTech tools such as ChatGPT, Gemini, Copilot, QuillBot, Gamma AI, Canva AI, and PhET Simulations. The inclusion criteria required respondents to have at least five years of teaching experience and a minimum of one year of experience integrating EdTech tools into science instruction. These criteria ensured that the respondents had sufficient teaching experience and direct exposure to the use of EdTech tools relevant to the study.

For the qualitative component, the study selected one participant purposively from each private school in the Districts of Pandi North and South in this study from the pool of respondents with a total of nine participants composed of science teachers and school administrators. Criteria for selecting the participant is same as how the respondents were qualified and since they were also on the pool of respondents, that should suffice the requirement, Purposive sampling was also employed to select participants who possessed relevant experiences in integrating EdTech tools in science instruction and were willing to participate in the interview process.

Research Instruments

This study utilized two research instruments: a self-made survey questionnaire and a key informant interview

For the quantitative component, the survey questionnaire was developed based on related literature and studies on the integration of EdTech tools in science instruction. The First part collected the demographic profile of schools, including location, size, and EdTech tools used such as ChatGPT, Gemini, Copilot, Quillbot, Gamma AI, Canva AI, PhET Simulations. The Second part explored the extent of EdTech tool implementation, employing a researcher-made questionnaire with 10 question statements to assess science teachers' extent of using EdTech in their science classes in terms of planning, instruction, and intervention and assessment. It was assessed through 4-point Likert scale with the following response set of: With high extent(4); moderate extent (3); with less extent (2); and none at all (1).

The Third part focused on the extent of teachers' perceived benefits of using EdTech tools, in terms of engagement, achievement, and collaboration with 10 question statements to assess science teachers' perspectives on the extent of benefits of these tools in science instruction using 4-point Likert scale with a response set of: most beneficial (4); beneficial (3); less beneficial (2) ; and not beneficial (1). (See Appendix D)

The research instrument underwent content validation by Expert A who is a Level Area Coordinator of the Senior High School Department at the University of Perpetual Help System DALTA Calamba Campus; Expert B, Head of Community Extension Services at the University of Perpetual Help System

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DALTA Las Piñas; and Expert C, Principal of the University of Perpetual Help System DALTA Calamba Campus. The validators evaluated the instrument using an Expert Evaluation Form which assessed the questionnaire in terms of comprehensiveness of content, clarity of language, usability, and general appearance using a five-point rating scale (refer to Appendix C).

A pilot test was subsequently conducted among 32 non-study participants from the District of Plaridel, Schools Division of Bulacan. The responses were subjected to reliability testing using Cronbach's Alpha to determine the internal consistency of the instrument. A Cronbach Alpha value generated was 0.898 which showed good reliability. (see Appendix F).

For the qualitative part, The Researcher-Made Semi-Structured interview guide will gather information regarding the significant experiences faced by science teachers in using EdTech Tools. It was composed of three main questions revolving around most common difficulties and addressing them as well as their best practices to mitigate certain EdTech tool issues . Sub-questions for each main question were also developed to further breakdown their experiences and have a deeper insight on their experiences. (Refer to Appendix E).

The instruments were reviewed by the research adviser and validated by the same panel of expert validators. The validators assessed the guide using an Expert Evaluation Form in terms of comprehensiveness of content, clarity of language, usability, and general appearance. The Expert Evaluation Form is the recommended tool provided by researcher's university.

Data Gathering Procedure

The study followed a structured process to collect data from the respondents' and participants' perceptions of EdTech tools integration, focusing on the extent of implementation, extent of perceived benefits, experiences and strategies with its use.

For the permit, a formal permission was obtained through a letter of intent addressed to science teachers, department heads, and school administrators in private schools within the Districts of Pandi North and South (see Appendix A).

Once permits are signed and approved, consent was sought after from the respondents and participants who had been able to meet the inclusion criteria set in this study. This consent was electronically signed using google forms and was sent on prefer emails addresses (See Appendix B).

After all consents have been signed and submitted, the survey questionnaires were distributed through Google Forms or printed copies based on the respondents' preference. They were given a week to complete the survey questionnaire and submit all scanned completed printed copies via email and shred the original papers for confidentiality purposes. All collected data and research materials were properly discarded and permanently deleted after the completion of the study.

For qualitative part, One-on-one Key Informant Interviews were conducted with selected participants. Audi video recording was done to capture both audio and video components ensuring a clear and concise gathering of significant experiences from the participants. In terms of scheduling, the researcher and participants communicated as to when would be a good time for interview in terms of date, day and time of the participants' convenience. The interviews were scheduled in coordination with the participants and were conducted through Zoom or Google Meet, with each session lasting approximately 30 to 45 minutes.

After the interview, the researcher made sure that the statements that will be utilized in the study provided by the generated transcripts of the video platform were true and correct based on what have been discussed by sending them a copy via email and getting approval from the participant validating the content. The interviews provided an opportunity to gather in-depth information regarding the significant experiences of the coparticipants and the strategies they employed to overcome challenges encountered in integrating EdTech tools in science instruction.

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Statistical Analysis of Data

For the quantitative part, the study utilized appropriate statistical tools to analyze and interpret the gathered data based on the Statement of the Problem.

Percentage Distribution was utilized to determine the proportion of each category. This was used for Statement of the Problem 1 (SOP 1), which focused on the demographic profile of the schools in terms of location, school size, and EdTech tools utilized such as ChatGPT, Gemini, Copilot, QuillBot, Gamma AI, Canva AI, and PhET Simulations.

Weighted Mean was employed to determine the extent of EdTech tool implementation and the extent of teachers' perceived benefits of using EdTech tools in science education. This statistical treatment was used for SOP 2 and SOP 3.

Group comparisons were conducted at the 0.05 significance level. The source methodology identifies the Kruskal–Wallis test, whereas the results tables label statistics as F-tests or t-tests; the actual procedure requires verification against the original statistical output.

Thematic Analysis

For the qualitative component, the study employed thematic analysis to analyze and interpret the responses gathered from the key informant interviews for SOP 6 and SOP 7. MAXQDA, a qualitative and mixed-methods data analysis software, was utilized to organize, code, and analyze the interview responses.

MAXQDA is a qualitative and mixed-methods data analysis program that researchers use to organize, code, analyze, and present data from sources such as interviews, documents, surveys, audio recordings, videos, and images. Particularly, it was utilized to interpret data gathered for SOP 6 and 7.

The qualitative data analysis followed the six phases of thematic analysis by Braun and Clarke (2006, as cited in Naeem et al., 2023).First, the researchers familiarized themselves with the data through repeated reading of the interview transcripts. Second, initial codes were generated by identifying significant statements and meaningful responses related to the research questions. Third, the generated codes were organized and grouped into potential themes using MAXQDA coding features. Fourth, the identified themes were reviewed and refined to ensure their relevance and consistency with the gathered data. Fifth, the themes were defined and named according to the central ideas reflected in the participants' responses. Lastly, the themes were interpreted and presented to provide meaningful descriptions and explanations regarding the experiences, challenges, and management strategies of science teachers and administrators in integrating EdTech tools in science instruction.

Ethical Consideration

This section guided the research process, ensuring that ethical research standards were strictly adhered.

This study sought approval from research related offices in the university. All institutional organizations were officially consulted prior to the start of the research. Throughout the study, adherence to ethical standards such as informed consent process and respondents and participants' rights were maintained.

In addition, respondents and co-participants were free to leave the study at any time without incurring penalties. Their freedom to leave won't affect their relationship with the researchers or any affiliated organizations.

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RESULTS

Respondent and School Profiles

Table 1. *Demographic Profile of the Respondents in Terms of School Location*

Location	Frequency	Percentage
District of Pandi North	21	65.6
District of Pandi South	11	34.4
Total	**32**	**100.0**

Based on the findings, 65.6% of the respondents were from the North District, while 34.4% were from the South District. The respondents' demographic profile indicates that the majority of the participating teachers were employed in schools located in the Northern District, while a smaller proportion came from the Southern District. This distribution suggests that the findings may reflect more extensively the perspectives and experiences of teachers from the Northern District regarding the use of educational technology (EdTech) in science education. However, the geographical distribution of the respondents should be considered when interpreting the findings, as the differences in the representation of the two districts may influence the extent to which the experiences of teachers from each area are reflected in the results. Furthermore, factors such as the availability of technological resources, infrastructure support, administrative assistance, professional development opportunities, and access to digital tools may also provide important contextual considerations in understanding teachers' experiences with EdTech integration.

Table 2. *Demographic Profile of the Respondents in terms of School Size*

School Size	Frequency	Percentage
501 - 1000 students	15	46.9
Less than 500 students	17	53.1
Total	**32**	**100.0**

Based on the findings, 53.1% (n = 17) of the respondents were employed in schools with a student population of fewer than 500, while 46.9% (n = 15) were from schools with a student population ranging from 501 to 1,000. The distribution indicates that the respondents were relatively evenly distributed between the two school population categories, although a slightly higher proportion came from schools with fewer than 500 students.

Table 3. *Demographic Profile of the Respondents in terms of EdTech Tools Used*

EdTech Tools Used	Frequency	Percentage
AI-Powered Tutors	25	78.1
PhET Interactive Simulations	7	21.9
Total	**32**	**100.0**

Based on the findings, the majority of the respondents (78.1%, n = 25) reported using AI-powered tutors as their EdTech tool, while a smaller proportion (21.9%, n = 7) utilized PhET Interactive Simulations.

Extent of EdTech Implementation

Table 4. *Extent of EdTech Tool Implementation in Science Classes in terms of Planning*

Indicators	Mean	SD	VI
1. I regularly integrate EdTech tools such as ChatGPT 3, Gemini, or Copilot in my science teaching. The EdTech tools that I am	3.09	0.641	Moderate Extent

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Indicators	Mean	SD	VI
using are aligned with the learning objectives.			
2. I frequently use AI tools like Quillbot to assist students in improving their writing tasks in science. The EdTech tools improve the students' writing tasks in science.	3.38	0.492	Moderately Extent
3. I often utilize slide-generating tools like Gamma AI and Canva AI to enhance my classroom presentations. The EdTech tools help me prepare my classroom presentation with efficiency.	3.13	0.751	Moderately Extent
Overall Mean	**3.20**	**0.358**	**Moderate Extent**

Note: 3.51 – 4.00 = With High Extent; 2.51 – 3.50 = Moderate Extent; 1.51 – 2.50 = With Less Extent; 1.00 – 1.50 = Not at All

The overall mean of 3.20 indicates that EdTech tools were moderately implemented in Science lesson planning. Among the indicators, the highest mean of 3.38 was obtained for the use of AI tools, such as QuillBot, to assist students in improving their Science writing tasks. In contrast, the lowest mean of 3.09 was recorded for regularly integrating EdTech tools, such as ChatGPT, Gemini, or Copilot, into Science teaching and aligning their use with learning objectives. Both indicators were interpreted as moderately implemented.

Table 5. *Extent of EdTech Tool Implementation in Science Classes in terms of Instruction*

Indicators	Mean	SD	VI
1. I use PHET Simulations as a regular part of science instruction to support interactive learning. The EdTech tools provide and support interactive learning.	3.09	0.689	Moderate Extent
2. I incorporate Google Expeditions with VR glasses in my science classes to facilitate virtual field trips. The EdTech tools help facilitate virtual field trips.	1.00	0.000	Not at All
3. I allow students to explore topics independently using AI-powered tutoring or chat tools during science lessons. The EdTech tools allow students to explore topics independently during science lessons.	2.72	0.772	Moderately Extent
4. I use EdTech tools to accommodate diverse student learning styles and needs in science subjects. The EdTech tools provide activities that accommodate diverse students' learning styles and needs in science subjects	3.38	0.492	Moderate Extent

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Indicators	Mean	SD	VI
Overall Mean	**2.55**	**0.307**	**Moderate Extent**

Note: 3.51 – 4.00 = With High Extent; 2.51 – 3.50 = Moderate Extent; 1.51 – 2.50 = With Less Extent; 1.00 – 1.50 = Not at All

As shown in the table, the overall mean of 2.55 indicates that EdTech tools was moderate extent in Science instruction. Among the indicators, the highest mean of 3.38 was recorded for using EdTech tools to provide activities that accommodate students' diverse learning styles and needs, interpreted as moderate extent. In contrast, the lowest mean of 1.00 was obtained for incorporating Google Expeditions with VR glasses to facilitate virtual field trips, interpreted as not at all.

Table 6. *Extent of EdTech Tool Implementation in Science Classes in terms of Intervention and Assessment*

Indicators	Mean	SD	VI
1. I integrate EdTech tools during science assessments or review sessions. The EdTech tools offer interactive assessment activities that measure students' skills while providing real-time feedback to support immediate learning adjustments.	2.97	0.822	Moderate Extent
2. I consistently include both AI and AR tools in my science lesson planning and delivery. The EdTech tools pique students' interest in learning science topics.	2.75	0.718	Moderate Extent
3. I encourage students to use EdTech tools outside the classroom to reinforce science learning. The EdTech tools can be used beyond the classroom to reinforce and deepen their understanding of science concepts.	3.38	0.492	Moderate Extent
Overall Mean	**3.03**	**0.409**	**Moderate Extent**

Note: 3.51 – 4.00 = Highly Implemented; 2.51 – 3.50 = Moderately Implemented; 1.51 – 2.50 = Slightly Implemented; 1.00 – 1.50 = Not Implemented at All

As shown in the table, the overall mean of 3.03 indicates that EdTech tools was moderate extent in Science classes in terms of intervention and assessment. Among the indicators, the highest mean of 3.38 was obtained for encouraging students to use EdTech tools beyond the classroom to reinforce and deepen their understanding of Science concepts, interpreted as moderate extent. In contrast, the lowest mean of 2.75 was recorded for consistently incorporating both AI and AR tools in Science lesson planning and delivery to stimulate students' interest in learning Science topics, also interpreted as moderate extent.

Perceived Benefits

Table 7. *Teachers' Perceived Benefits of Using EdTech Tools in Science Education in terms of Engagement*

Engagement	Mean	SD	VI
1. Slide-generation tools like Gamma AI and Canva AI support teachers in creating engaging and visually appealing science presentations for students (Olatunde-Aiyedun, 2023) .	3.41	0.499	Agree

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Engagement	Mean	SD	VI
2. Google Expeditions, when used with VR glasses, enhances students' learning experiences by allowing them to take virtual field trips, such as exploring the solar system or the human body in 3D (Parmaxi et al., 2021).	3.38	0.492	Agree
3. AI-based feedback tools (e.g., ChatGPT 3, Gemini, Copilot) provide instant responses to student queries, improving engagement and independent learning (Senechal et al., 2023; Alhusaiyan, 2024).	3.53	0.507	Strongly Agree
Overall Mean	**3.44**	**0.499**	**Agree**

Note: 3.51 – 4.00 = Strongly Agree; 2.51 – 3.50 = Agree; 1.51 – 2.50 = Disagree; 1.00 – 1.50 = Strongly Disagree

Table 7 presents the teachers' perceived benefits of using EdTech tools in science education in terms of student engagement. The three indicators obtained an overall mean of 3.44, interpreted as agree, indicating that the respondents generally perceived EdTech tools as beneficial in promoting student engagement in science learning.

Among the indicators, the highest mean of 3.53 was obtained for the use of AI-based feedback tools, such as ChatGPT, Gemini, and Copilot, to provide immediate responses to students' queries and support engagement and independent learning (Senechal et al., 2023; Alhusaiyan, 2024). This was interpreted as strongly agree. In contrast, the lowest mean of 3.38 was recorded for the use of Google Expeditions with VR glasses to enhance students' learning experiences through virtual field trips, such as exploring the solar system and the human body in 3D (Parmaxi et al., 2021). This indicator was interpreted as agree.

Table 8. *Teacher's Perceived Benefits of Using EdTech Tools in Science Education in terms of Achievement*

Achievement	Mean	SD	VI
1. AI-powered tools such as ChatGPT 3, Gemini, and Copilot provide real-time explanations, assisting students in understanding complex science concepts more effectively (Yilmaz, 2023; Al-Obaydi & Pikhart, 2026) .	3.44	0.504	Agree
2. Text-enhancement AI like Quillbot helps students refine scientific reports and improve their academic writing skills in science-related projects (Nurmayanti & Suryadi, 2023).	3.56	0.504	Strongly Agree
3. PHET Simulations allow students to perform virtual science experiments, making it easier to explore physics and chemistry concepts without the need for a physical lab (Ben Ouahi et al., 2022) .	3.38	0.492	Agree
4. Using VR glasses with Google Expeditions promotes interactive learning, helping students visualize and retain information better than traditional textbooks (Graeske & Sjöberg, 2021).	3.59	0.499	Strongly Agree
Overall Mean	**3.49**	**.500**	**Agree**

Note: 3.51 – 4.00 = Strongly Agree; 2.51 – 3.50 = Agree; 1.51 – 2.50 = Disagree; 1.00 – 1.50 = Strongly Disagree

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Table 8 presents the findings with an overall mean of 3.49, interpreted as agree, indicating that the respondents generally perceived EdTech tools as beneficial in supporting student achievement. Among the indicators, the highest mean of 3.59 was obtained for the use of VR glasses with Google Expeditions to promote interactive learning and help students visualize and retain information better than through traditional textbooks (Graeske & Sjöberg, 2021). This was interpreted as strongly agree. In contrast, the lowest mean of 3.38 was recorded for the use of PhET Simulations to facilitate virtual science experiments and help students explore Physics and Chemistry concepts without requiring a physical laboratory (Ben Ouahi et al., 2022). This was interpreted as agree.

Table 9. *Teachers' Perceived Benefits of Using EdTech Tools in Science Education in terms of Collaboration*

Collaboration	Mean	SD	VI
1. AI-driven tools assist teachers in lesson planning, allowing for the customization of science lessons to fit different learning styles and needs (Örnek, 2025).	3.53	0.507	Strongly Agree
2. The integration of AI and AR tools in science instruction enhances students' problem-solving and critical thinking skills, preparing them for STEM-related careers (National Center for Computer Education, 2024).	3.50	0.508	Agree
3. Students show increased motivation and interest in learning science when AI-powered tutoring and AR-based simulations are incorporated into lessons (Kuanbayeva et al., 2024).	3.50	0.508	Agree
Overall Mean	**3.51**	**0.508**	**Strongly Agree**

Note: 3.51 – 4.00 = Strongly Agree; 2.51 – 3.50 = Agree; 1.51 – 2.50 = Disagree; 1.00 – 1.50 = Strongly Disagree

The findings revealed an overall mean of 3.51, indicating that Science teachers and school administrators perceived EdTech tools as highly beneficial as many of them agreed on the statements in promoting student collaboration. Among the indicators, the highest mean of 3.53 was obtained for the use of AI-driven tools to assist teachers in lesson planning and customize Science lessons according to students' diverse learning styles and needs (Örnek, 2025). This was interpreted as Strongly Agree. In contrast, the lowest means of 3.50 were obtained by two indicators: the integration of AI and AR tools in Science instruction to enhance students' problem-solving and critical-thinking skills and prepare them for STEM-related careers (National Center for Computer Education, 2024), and the use of AI-powered tutoring and AR-based simulations to increase students' motivation and interest in Science learning (Kuanbayeva et al., 2024). Both indicators were interpreted as agree.

Group Differences in Implementation

Table 10. *Significant Difference in the Extent of Implementation of EdTech Tools in Science Education When Respondents Are Grouped According to School Location*

Variable	F-test value	P-value	Decision	Interpretation
Planning	2.676	0.031	Reject H_0	Significant
Instruction	2.613	0.034	Reject H_0	Significant

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Variable	F-test value	P-value	Decision	Interpretation
Intervention & Assessment	0.725	0.668	Failed to Reject H_0	Not Significant

Note: Significance level = 0.05.

Table 11. *Significant Difference in the Extent of Implementation of EdTech Tools in Science Education When Respondents Are Grouped According to School Size*

Variable	T-test value	P-value	Decision	Interpretation
Planning	0.740	0.397	Failed to Reject H_0	Not Significant
Instruction	0.068	0.797	Failed to Reject H_0	Not Significant
Intervention & Assessment	1.144	0.293	Failed to Reject H_0	Not Significant

Note: Significance level = 0.05.

Table 12. *Significant Difference in the Extent of Implementation of EdTech Tools in Science Education When Respondents Are Grouped According to the EdTech Tools Used*

Variable	t-test value	P-value	Decision	Interpretation
Planning	5.560	0.025	Reject H_0	Significant
Instruction	0.177	0.677	Failed to Reject H_0	Not Significant
Intervention & Assessment	0.009	0.924	Failed to Reject H_0	Not Significant

The reported p-values indicate significant differences in planning and instruction by location (0.031 and 0.034), and planning by tool type (0.025). All other implementation comparisons were nonsignificant. The direction of these differences cannot be determined from the reported statistics alone.
Note: Significance level = 0.05.

Group Differences in Perceived Benefits

Table 13. *Significant Difference in Extent of Teachers' Perceived Benefits of EdTech Tools when Respondents Are Grouped According to School Location*

Variable	F-test value	P-value	Decision	Interpretation
Extent of Teachers' Perceived Benefits of EdTech Tools in Science Education with regards to Location – Engagement	0.737	0.659	Failed to Reject H_0	Not Significant
Extent of Teachers' Perceived Benefits of EdTech Tools in Science Education with regards to Location – Achievement	0.795	0.612	Failed to Reject H_0	Not Significant
Extent of Teachers' Perceived Benefits of EdTech Tools in Science Education with regards to Location – Collaboration	0.970	0.482	Failed to Reject H_0	Not Significant

Note: Significance level = 0.05.

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Table 14. *Significant Difference in Extent of Perceived Benefits of EdTech Tools When Respondents Are Grouped According to School Size*

Variable	F-test value	P-value	Decision	Interpretation
Extent of Perceived Benefits of EdTech Tools in Science Education with regards to School Size – Engagement	0.613	0.440	Failed to Reject H_0	Not Significant
Extent of Perceived Benefits of EdTech Tools in Science Education with regards to School Size – Achievement	0.611	0.440	Failed to Reject H_0	Not Significant
Extent of Perceived Benefits of EdTech Tools in Science Education with regards to School Size – Collaboration	0.090	0.766	Failed to Reject H_0	Not Significant

Note: Significance level = 0.05.

Table 15. *Significant Difference in Extent of Teachers' Perceived Benefits of EdTech Tools When Respondents Are Grouped According to the EdTech Tools Used*

Variable	F-test value	P-value	Decision	Interpretation
Extent of Teachers' Perceived Benefits of EdTech Tools in Science Education with regards to EdTech Tools – Engagement	0.122	0.730	Failed to Reject H_0	Not Significant
Extent of Teachers' Perceived Benefits of EdTech Tools in Science Education with regards to Ed-Tech Tools – Achievement	0.255	0.618	Failed to Reject H_0	Not Significant
Extent of Teachers' Perceived Benefits of EdTech Tools in Science Education with regards to Ed-Tech Tools – Collaboration	1.962	0.172	Failed to Reject H_0	Not Significant

All reported comparisons of perceived benefits were nonsignificant at the 0.05 level.

Note: Significance level = 0.05.

Qualitative Findings

Nine key informants described their experiences of integrating EdTech into science instruction. Five themes are presented in the source analysis.

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Table 16. *Themes Generated from the Lived Experiences of Science Teachers in Integrating EdTech Tools into Science Instruction*

Initial Code	Sub-Themes	Themes
1. Lack of internet connection in some schools	1. Connectivity issues during EdTech integration	**Theme 1: Navigating Infrastructure and Internet Connectivity Constraints**
2. Unstable internet connection	2. Limited digital infrastructure in schools	
3. Students without gadgets	4. Digital divide among learners	**Theme 2: Navigating Unequal Student Access to Digital Devices and Technology**
5. Lack of internet access among students	6. Socioeconomic barriers to digital learning	
7. Limited knowledge of EdTech tools	8. Lack of training and technological competence	**Theme 3: Navigating Gaps in Teachers' Knowledge and Professional Development**
9. Difficulty using AI tools due to errors	10. Uncertainty and lack of confidence in AI integration	
11. Student hesitation in using technology	12. Uncertainty in using EdTech tools	**Theme 4: Students' Hesitation in Using EdTech and Emerging Dependence on AI Tools**
13. Overreliance on AI tools	14. Reduced attention and engagement	
15. AI making students dependent	16. Concerns about AI affecting learning behavior	
17. Being resourceful and taking the initiative	20. Resourcefulness, preparedness, and instructional flexibility	**Theme 5: Teachers' Adaptive Strategies in Managing Technology-Related Challenges**
18. Using blended and traditional teaching as a backup plan		
19. Preparing ahead of time and developing offline teaching strategies		
21. Maintaining student engagement through game-based and visual strategies	23. Promoting student engagement and responsible technology use	
22. Using AI tools in a responsible and guided manner		

Theme 1: ***Navigating Infrastructure and Internet Connectivity Constraints***

It captures the shared experience of teachers who wanted to integrate EdTech tools but had to adjust their instructional practices because of unreliable internet access and inadequate infrastructure. The participants' narratives revealed that inadequate technological infrastructure, particularly unreliable internet connectivity, was a significant challenge in their experiences of integrating EdTech tools into science instruction. They described difficulties associated with weak internet signals, unstable connections, and limited internet access within their school environments. Although they recognized the instructional

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potential of AI applications, simulations, videos, and other digital resources, their ability to utilize these technologies was often constrained by the availability and reliability of internet connectivity.

One participant described having to rely on a personal mobile phone to establish an internet connection whenever school connectivity was unavailable: P1- "One of the challenges that I have faced is the unavailability of internet… whenever I'm using that, I have to use my phone to connect that to my laptop so that I could present it to my class." Similarly, another participant identified internet connectivity as a primary concern: P3- "Parang ang difficulties lang naman po is yung sa talagang connection Sir." The participant further explained that the geographical location of the school presented additional connectivity difficulties: "Kasi parang sa Pandi po parang medyo mahina po ang mga signal."

The experience of unreliable connectivity was also reflected during the interview with another participant, who encountered difficulty maintaining a stable connection while sharing their experiences: P4- "Sorry Sir ha, my internet connection is unstable. Medyo matagal lang ako magsalita—hindi ko naririnig."

Taken together, these accounts illustrate how unreliable internet connectivity shaped the participants' experiences of using EdTech tools in science instruction. For some teachers, the absence of dependable school internet access meant having to rely on personal devices and mobile data to carry out technology-supported lessons. For others, weak signals and intermittent connections presented difficulties in accessing and utilizing digital resources. These experiences suggest that the integration of EdTech tools involved not only teachers' willingness and ability to use technology but also their capacity to work around the limitations of their technological environment.

The underlying meaning of this theme reflects the tension between teachers' intentions to incorporate technology into science instruction and the infrastructural limitations that constrain its actual implementation. Reliable internet connectivity emerged as an essential condition for accessing digital resources and sustaining technology-enhanced classroom activities. Thus, the participants experienced infrastructure not merely as a technical requirement but as a factor that shaped the extent to which they could carry out their intended instructional practices. Their accounts highlight the importance of strengthening school connectivity and providing adequate technological infrastructure to support the meaningful and equitable integration of EdTech tools in science education.

The essence of this theme is that teachers' efforts to integrate EdTech tools into Science instruction are shaped and constrained by the reliability of the technological infrastructure available to them. Despite their willingness to use AI applications, simulations, videos, and other digital resources to enrich Science instruction, unreliable internet connectivity, weak signals, and limited school internet access hinder their ability to implement these technologies consistently. Consequently, teachers experience technology integration not simply as a matter of pedagogical choice or technological competence but as a continuing process of adapting to infrastructural limitations. Their experiences reveal that meaningful technology integration requires not only teachers' readiness and willingness but also dependable technological infrastructure that enables them to translate their instructional intentions into actual classroom practices.

Theme 2: ***Navigating Unequal Student Access to Digital Devices and Technology***

Theme 2 focuses on the challenges teachers experience when integrating EdTech tools because students do not have equal access to the digital resources needed for technology-supported learning. The participants' narratives revealed that unequal access to digital devices and internet connectivity among students presented another challenge in integrating EdTech tools into science instruction. They described how some learners lacked personal gadgets and reliable internet access, limiting their opportunities to participate in technology-supported activities and continue learning beyond the classroom. The participants

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emphasized that students' difficulties in using EdTech tools were not necessarily due to a lack of willingness or interest but were often associated with their limited access to the necessary technological resources.

One participant shared that some students experienced difficulties keeping up with technology-supported learning because they did not have personal devices: P6- "Yung iba po kasi, based on my experience, yung iba, wala pong gadget. So parang nahuhuli po talaga sila." And further explained how the lack of devices affected students' opportunities to practice and reinforce their learning at home:"Kaya minsan kahit na gusto namin ituro ay wala po silang mapagpa-praktisan kapag nasa bahay na po sila."

Another participant emphasized that limited access to gadgets and internet connectivity made it difficult for some students to adapt to technology-supported learning: P7- "Especially those students that they don't have any gadgets to use… not all are capable… they don't have internet… that's why it's very hard for them to adapt."

Similarly, another participant described the difficulties experienced by learners who had limited access to digital devices and technology: P1- "Those students who are not—have access to gadgets and to technology—most of them are really struggled to use those tools."

Taken together, these accounts illustrate how differences in students' access to digital devices and internet connectivity shaped the participants' experiences of implementing EdTech tools. Teachers recognized that not all learners had the same opportunities to engage with technology-supported activities. While some students could access digital resources and practice using educational applications beyond school, others depended on the limited opportunities available within the classroom. This situation created difficulties in sustaining technology-enhanced learning experiences and ensuring that all students could participate meaningfully.

The underlying meaning of this theme reflects the tension between the opportunities offered by educational technology and the unequal conditions under which students access these opportunities. For the participants, integrating EdTech tools meant recognizing that the availability of digital learning resources did not automatically translate into equal learning opportunities for all students. Students' access to devices and internet connectivity shaped their capacity to participate, practice, and extend their science learning beyond the classroom. Thus, the digital divide was experienced not merely as a difference in technological ownership but as an inequality in students' opportunities to benefit from technology-enhanced instruction.

The essence of this theme is that the integration of EdTech tools in Science instruction is experienced within unequal conditions of student access to digital devices and internet connectivity. Although teachers seek to provide technology-enhanced learning opportunities, some students cannot fully participate or continue learning beyond the classroom because they lack the necessary resources. Consequently, teachers experience the challenge of providing technology-supported instruction in a learning environment where students do not have equal opportunities to access and benefit from digital technologies.

Theme 3: ***Navigating Gaps in Teachers' Knowledge and Professional Development***

The participants' narratives revealed that limited knowledge, inadequate training, and insufficient professional development opportunities presented challenges in integrating EdTech tools into Science instruction. They described varying levels of familiarity and confidence in using educational technologies, particularly AI- and AR-based applications. Although they recognized the potential of these tools to support teaching and learning, some participants expressed uncertainty about how to use them effectively and incorporate them into their instructional practices. Their experiences also highlighted the need for continuous training and opportunities to develop the knowledge and skills necessary for meaningful technology integration.

One participant emphasized the importance of strengthening teachers' knowledge and providing opportunities for professional training: P5- "The second one is the teacher's knowledge about how to use different ed-tech tools… kailangan ng mga seminars, workshops to train teachers para matutunan kung paano i-apply yung mga different ed-tech tools in their classes." Similarly, P8 acknowledged having limited

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knowledge of some educational technologies, which made it difficult to integrate these tools into science instruction: P8-"Like for me, I'm not really that aware po in some of the ed-tech, so limited knowledge lang po. So, big problem po yun." The participant further explained that teachers' limited understanding of EdTech tools could affect their ability to explain their use and guide students in accessing and utilizing them: P9- "Hindi siya ganon kalawak sa kaalaman, so nahihirapan din siyang mag-explain. Of course, kung nahihirapan si teacher, the students will also get difficulty when it comes to accessing ed-tech tools." Recognizing this concern, P9 emphasized the importance of providing teachers with appropriate training and professional development to strengthen their ability to use these technologies and guide students effectively: P8- "Ang pinaka-una kasi dapat diyan ay magkaroon ng training talaga when it comes to the teacher para maturo niya nga mabuti sa student… inadequate training. Professional development din kasi yan para sa mga teachers."

In the absence of school-based training, some participants took the initiative to develop their proficiency through independent exploration of available technologies. One participant described relying on self-learning to become more familiar with AI tools so that they could respond to students' questions and provide appropriate guidance: P3- "Wala pa namang… hindi pa po sila nagco-conduct sa school ng training about AI… ako na lang… ine-explore ko po yung mga AI na ginagamit para kapag may tanong po yung mga bata, masasabayan ko or masasagot ko po yung mga tanong nila."

Another participant shared a similar experience, explaining that attending seminars had provided some exposure to AI tools but had not fully addressed the need for deeper understanding and practical knowledge: P4- "More on self-learning pero… I attended at least two seminars using AI tools… pero I think it is still insufficient pa rin nga. Kailangan ng mas malalim pa."

Taken together, these accounts illustrate how teachers' experiences of integrating EdTech tools involved continuous efforts to develop their technological knowledge and instructional competence. While some participants recognized gaps in their familiarity with available tools, others described taking personal initiatives to explore and learn how these technologies could be used in their classes. However, their reliance on self-directed learning also reflected the limited availability or perceived insufficiency of formal training and school-based professional development. These experiences suggest that knowing about a particular technology is not necessarily equivalent to knowing how to use it purposefully in Science instruction. Teachers also need opportunities to develop practical skills, understand the instructional applications of these tools, and learn how to guide students in using them.

The underlying meaning of this theme reflects the participants' experience of technology integration as a continuing process of professional learning. Their accounts reveal a gap between recognizing the instructional potential of EdTech tools and having sufficient knowledge, confidence, and practical competence to integrate them effectively. Although some teachers respond to this challenge through independent exploration and attendance at available seminars, these efforts do not always provide the depth of learning they consider necessary. Thus, teachers experience EdTech integration not simply as the adoption of new technologies but as an ongoing professional responsibility that requires sustained learning, structured training, and opportunities for collaboration and development.

The essence of this theme is that teachers experience the integration of EdTech tools into Science instruction as a continuing process of acquiring knowledge, developing skills, and building confidence. Limited familiarity with educational technologies and insufficient formal training create difficulties in using these tools and guiding students in their application. In response, some teachers engage in self-directed learning and seek available training opportunities, although these efforts may not fully address their professional learning needs. Their experiences reveal that meaningful technology integration requires more than access to digital tools; it also requires sustained professional development that enables teachers to understand, use, and pedagogically integrate these technologies into Science instruction.

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Theme 4: ***Students' Hesitation in Using EdTech and Emerging Dependence on AI Tools***

The participants' narratives revealed contrasting student responses to the integration of EdTech tools in Science instruction. Some students exhibited hesitation and reluctance to participate when they were unfamiliar with the technologies being introduced. Others raised concerns about students' increasing reliance on AI applications, particularly ChatGPT, in completing academic tasks. These experiences highlight the challenges teachers encounter in helping students become comfortable with educational technologies while also encouraging their responsible and independent use.

One participant described how students' unfamiliarity with EdTech tools could make them hesitant to participate in technology-supported activities: P1- "If they are not familiar with those tools, they are hesitant to participate." The same participant further explained that some students would simply observe the technology rather than attempt to use it: P1- "They are not used to it. They will just simply look at it and hesitant to try." Similarly, another participant observed that unfamiliarity with EdTech tools could affect students' willingness to engage in classroom activities: P4- "Sometimes they are demotivated to join kasi they are not familiar."

These accounts illustrate how students' lack of familiarity with educational technologies may create uncertainty and hesitation in participating in technology-supported learning activities. Rather than immediately exploring or using unfamiliar tools, some students tend to remain passive, suggesting that exposure to technology does not automatically translate into willingness or confidence to use it.

In contrast, other participants expressed concerns about students becoming overly dependent on AI applications when completing academic requirements. One participant observed that students frequently use ChatGPT when writing essays, making it difficult for teachers to determine whether submitted outputs reflect students' own work: P5- "I have noticed a lot of students talaga use ChatGPT in doing their essays. So it really is challenging for us to check if their works talaga are personally made by them or AI generated." Another participant raised concerns about the possible effect of AI use on students' attention during classroom discussions: P2- "The students… don't give attention to what your lesson is being discussed because of the ChatGPT and AI."

These accounts reflect teachers' concerns about how students engage with AI technologies in academic settings. While AI applications can provide assistance in completing learning tasks, their use may raise questions about students' independent work, attentiveness, and responsibility in learning. In particular, teachers face the challenge of determining whether students are using AI as a supplementary learning resource or relying on it to perform tasks that are expected to demonstrate their own understanding and effort.

Taken together, the participants' accounts reveal two contrasting dimensions of students' experiences with EdTech integration. On one hand, unfamiliarity with digital tools may lead to hesitation, reduced participation, and difficulty engaging in technology-supported activities. On the other hand, familiarity and frequent use of AI applications may raise concerns about excessive dependence, particularly when students rely on these tools to complete academic tasks or when their use appears to interfere with classroom attentiveness. Thus, teachers experience the integration of EdTech not only as a matter of introducing students to new technologies but also as a process of helping them develop the confidence, judgment, and responsibility needed to use these tools appropriately.

The essence of this theme is that students' engagement with educational technology is characterized by contrasting experiences of uncertainty and dependence. Students who are unfamiliar with EdTech tools may hesitate to explore and participate in technology-supported learning activities, while those who frequently use AI applications may develop patterns of reliance that concern their teachers. These experiences reveal the challenge of fostering students' confidence and meaningful participation while ensuring that technology serves as a support for, rather than a substitute for, their own thinking, learning, and academic responsibility.

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Theme 5: ***Teachers' Adaptive Strategies in Managing Technology-Related Challenges***

This theme focuses on how teachers demonstrate resourcefulness, flexibility, and preparedness to sustain Science instruction despite limitations in technological resources and internet connectivity.

Sub Theme 1: Resourcefulness, Preparedness, and Instructional Flexibility. This subtheme highlights how teachers demonstrate resourcefulness, initiative, and instructional flexibility in responding to technological limitations that affect the integration of EdTech tools in Science instruction. It captures how they anticipate potential difficulties, maximize available resources, prepare alternative instructional materials, and adjust their teaching approaches to ensure continuity of learning when technology is unavailable or cannot be used effectively. The participants described various ways of sustaining their lessons despite intermittent internet connectivity, limited access to digital devices, and inadequate technological resources in their schools. Their strategies included using personal mobile data and devices, downloading instructional videos and presentations for offline use, preparing alternative learning materials in advance, and shifting to traditional teaching approaches when technology was unavailable or impractical to use.

One participant described using a personal mobile phone to provide internet connectivity when the school's internet connection was unavailable: P1- "I have to use my phone to connect that to my laptop so that I could present it to my class." The same participant explained that downloading and preparing presentations for offline use allowed lessons to continue even without an internet connection: P1- "I'm just downloading… setting my presentation into offline so that I could teach and still present it even without the availability of internet connection." Similarly, another participant emphasized the importance of preparing instructional materials ahead of time, particularly videos that could be used when connectivity problems occurred: P3- "Tuwing gabi po kasi ina-advance ko na… dinadownload ko na yung video presentation… para if ever na mawalan po ng connection may mai-pa-present pa rin po ako para sa mga bata."

These accounts illustrate how teachers anticipated possible interruptions and took proactive measures to prevent technological difficulties from disrupting their lessons. Rather than relying entirely on real-time internet access, they prepared downloadable resources that could be accessed offline. Such practices reflect their capacity to adjust instructional preparations to the technological conditions of their schools.

Resourcefulness was also evident in the participants' willingness to maximize the devices available to them. One participant described allowing students to borrow a personal laptop to participate in technology-supported activities: P4- "The students will use my own laptop… you will let your students borrow your own device." Another participant highlighted the importance of conducting personal research and downloading instructional materials to help students understand and keep up with the lesson: P2- "I have to research… I have to use that to download subjects… so my students may cope up with my lesson." These experiences reveal how teachers addressed resource limitations by drawing on their personal resources and taking additional initiatives to provide learning opportunities for their students. Their accounts suggest that technology integration sometimes required personal contributions beyond the resources formally provided by the school, including the use of personal devices, time, and effort.

Aside from preparing alternative materials and maximizing available resources, teachers also demonstrated instructional flexibility by shifting to traditional teaching approaches when technology could not be used effectively. One participant briefly described this adjustment: P1 "I go back to traditional." This response reflects the participants' recognition that technology-based instruction is not always feasible under certain classroom conditions. When technological difficulties arise or circumstances do not permit the use of EdTech tools, teachers may return to familiar instructional approaches to maintain lesson continuity. Rather than viewing traditional and technology-supported instruction as mutually exclusive, their experiences suggest that teachers use them as complementary approaches, depending on the needs of the lesson and the resources available.

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Taken together, these accounts illustrate how teachers sustain Science instruction through resourcefulness, advance preparation, and instructional flexibility. They do not simply abandon technology when difficulties arise; instead, they explore alternative ways of accessing and presenting instructional materials, maximize available devices, and adjust their teaching approaches when necessary. These strategies demonstrate their efforts to maintain instructional continuity despite limitations in their technological environment.

The underlying meaning of this subtheme reflects teachers' experience of technology integration as a process that requires continuous adjustment and practical decision-making. Their ability to implement EdTech tools depends not only on the availability of technology but also on their capacity to anticipate difficulties, improvise with available resources, and modify instructional approaches when circumstances demand it. However, their reliance on personal devices, mobile data, and individual preparation also reveals how teachers sometimes compensate for limitations in institutional technological support.

The essence of this subtheme is that teachers experience the integration of EdTech tools as a continuing process of adaptation in response to technological and resource-related limitations. Through personal initiative, advance preparation, and flexible instructional approaches, they find ways to sustain Science lessons even when internet connectivity, digital devices, or other technological resources are inadequate. Their experiences demonstrate that meaningful technology integration requires not only access to digital tools but also teachers' resourcefulness and preparedness to adjust their practices. At the same time, their reliance on personal resources highlights the additional effort involved in sustaining technology-supported instruction in resource-constrained school environments.

Subtheme 5.2: Promoting Student Engagement and Responsible Technology Use. This subtheme highlights how teachers use engaging instructional strategies and provide guidance to help students maximize the learning opportunities offered by educational technologies. It captures their efforts to sustain students' interest through game-based and visual learning activities while promoting the responsible and appropriate use of AI tools. These practices reflect teachers' recognition that technology integration involves not only making lessons more interactive but also guiding students to use digital resources meaningfully and responsibly.

Keeping Students Interested Through Game-Based and Visual Strategies. The participants emphasized the importance of incorporating games, images, and multimedia resources to make Science lessons more engaging and encourage student participation. They recognized that presenting lesson content through interactive and visually stimulating activities could capture students' attention and make scientific concepts more accessible. One participant shared that students tend to show greater interest when lessons incorporate game-based activities: P8- “Mas gusto ng bata kapag inintegrate mo sa laro yung topic.” Similarly, another participant (P2) emphasized the use of visual and multimedia materials as an alternative way of presenting lesson content and sustaining students' interest. These accounts illustrate how teachers recognize the value of interactive and visual strategies in facilitating student engagement. By incorporating games, images, and multimedia presentations, they seek to make Science lessons more appealing and provide students with varied ways of encountering and understanding scientific concepts. Such strategies also demonstrate teachers' initiative in making instruction engaging, particularly when the use of more advanced EdTech tools is limited.

The participants' experiences suggest that student engagement does not depend solely on the availability of sophisticated technologies. Teachers can also sustain students' interest through creative instructional approaches that make learning activities interactive, visually meaningful, and responsive to students' needs.

Guiding Students Toward Responsible Use of AI Tools. Aside from promoting engagement, the participants also recognized the importance of guiding students in using AI applications responsibly. They emphasized that AI-generated information should not be accepted without question but should be examined and verified using reliable instructional materials and other sources of information.

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One participant explained that students may use ChatGPT, provided that they support and verify the information it generates using appropriate learning references: P8- "You can use your ChatGPT, but you have to do it responsibly by referenc(ing) your tuitional material." This statement reflects the participant's view that AI applications can serve as supplementary learning resources, but their use should be accompanied by appropriate verification and reference to instructional materials. Rather than discouraging students from using AI tools altogether, the participant emphasized the importance of developing responsible practices when accessing and using AI-generated information.

The account further highlights the teacher's role in helping students distinguish between using AI to support learning and relying on it without examining the accuracy or relevance of its outputs. Such guidance encourages students to engage critically with AI-generated information and recognize the importance of using credible sources when completing academic tasks.

Taken together, these accounts illustrate two complementary dimensions of teachers' efforts to make technology-supported learning meaningful. On one hand, they use game-based and visual strategies to sustain students' interest and participation in Science lessons. On the other hand, they guide students in using AI applications responsibly by emphasizing verification and reference to reliable learning materials. These practices demonstrate that effective technology integration involves not only the selection and use of digital tools but also the pedagogical guidance necessary to ensure that these tools contribute meaningfully to students' learning.

The essence of this subtheme is that teachers experience technology integration as both an opportunity to enrich student engagement and a responsibility to guide students' interaction with digital information. Through game-based and visual strategies, they seek to make Science learning more interesting and accessible. At the same time, they emphasize the responsible use of AI by encouraging students to verify generated information and consult reliable instructional materials. Their experiences reveal that meaningful technology integration requires a balance between making learning engaging and developing students' capacity to use digital technologies thoughtfully, critically, and responsibly.

The essence of Theme 5: Teachers' Adaptive Strategies in Managing Technology-Related Challenges is that teachers experience the integration of EdTech tools as a continuing process of adaptation, resourcefulness, and purposeful instructional decision-making. Faced with limitations in internet connectivity, digital devices, and technological resources, they take the initiative to prepare alternative instructional materials, maximize available resources, and adjust their teaching approaches to sustain Science instruction. At the same time, they seek to make technology-supported learning engaging through game-based and visual strategies while guiding students toward the responsible use of AI tools. These experiences reveal that meaningful technology integration extends beyond the availability and use of digital technologies; it requires teachers' ability to respond flexibly to instructional challenges, sustain student participation, and ensure that technology supports rather than replaces meaningful learning and independent thinking.

Essence of the Lived Experiences of the Participants

The lived experience of science teachers in integrating educational technology into science instruction is characterized by a continuous process of navigating limitations, developing capabilities, and adapting instructional practices to make technology meaningful in the teaching and learning process. Their experiences are shaped by the availability and reliability of technological infrastructure, students' unequal access to digital devices, and varying levels of teachers' knowledge and preparedness in using educational technologies. They also encounter students who may hesitate to use unfamiliar tools or become overly dependent on AI-generated information, presenting additional demands for instructional guidance and responsible technology use. In response, teachers draw on their resourcefulness, initiative, and professional judgment by preparing alternative learning materials, maximizing available resources, adjusting instructional approaches, and employing engaging strategies to sustain students' participation. They

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likewise recognize the importance of guiding students in using AI tools responsibly and verifying information through appropriate learning resources.

Ultimately, the essence of this phenomenon lies in the teachers' understanding that meaningful EdTech integration is not merely the adoption or utilization of digital tools, but an ongoing process of pedagogical adaptation, professional learning, and responsible instructional decision-making amid varying technological and learning conditions. Through these experiences, teachers strive to ensure that technology remains a purposeful means of facilitating Science learning rather than an end.

Integration of Quantitative and Qualitative Findings

Following the separate analysis of the quantitative and qualitative strands, the findings were integrated to provide a comprehensive interpretation of teachers' experiences with the integration of EdTech Tools in teaching science. The quantitative results established patterns in teachers' engagement in the implantation of EdTech tools and its perceived benefits, while the qualitative findings explained and elaborated on these patterns through the participants' lived experiences and perspectives. In accordance with the convergent parallel design, the two strands were compared and interpreted together to identify areas of convergence, complementarity, and divergence. The resulting integration provided a basis for developing meta-inferences that capture what can be understood from the quantitative and qualitative evidence when considered together.

Quantitative Findings	Corresponding Qualitative Findings	Convergence	Interpretation
No perceived benefit in teaching health due to **inadequate time and an overloaded syllabus.**	*"We have a very tight schedule and an overloaded syllabus, which makes it hard to teach health."*	Convergent	The quantitative and qualitative results both indicate that time constraints and an overloaded syllabus hinder health instruction.
Education on health was determined as **important based on the moderately favorable response.**	*"It is important and useful because it helps us maintain good health and healthy habits."*	Convergent	Both results highlight the importance of health education for promoting wellness and healthy habits among students.

Figure 2. Joint display of quantitative and qualitative findings (source Table 24)

DISCUSSION

Bacolod (2022) mentioned that certain technological capacities is being emphasized depending on location. These critical conditions draws a line for technological access. It was further explained by Bacolod (2022) that enabling environment for EdTech tools to flourish has been proven to address existing barriers in the learning of science education.

The findings also provide context for the succeeding tables, particularly those examining the availability of internet connectivity at home in relation to the respondents' geographical location. A UNICEF report (2020) during the COVID-19 epidemic indicates that globally, two-thirds of children and young individuals aged 25 and under lack a home internet connection. With this, EdTech tool as being a focus on this study can be affected in terms of many aspects depending on the location. In this regard, it may be asserted that a significant barrier to technological integration is the issue of internet accessibility (De Guzman, 2022).

The relatively balanced distribution of respondents across the two school population categories provides perspectives from teachers employed in both smaller and larger school settings. This suggests that the findings may capture varying experiences in the implementation of EdTech tools in Science instruction

across schools with different student populations. Differences in school size may also present varying considerations in terms of technological infrastructure, resource allocation, classroom management, and institutional support. For instance, schools with larger student populations may face greater demands in providing equitable access to digital resources, while smaller schools may encounter different challenges related to the availability and maintenance of technological facilities. These considerations provide a useful context for understanding the perceived benefits, implementation practices, and challenges associated with EdTech integration in Science instruction.

The findings presented in Table 2 may be contextualized by Kim and Lee (2020), who emphasized that educators' implementation of ICT-based instruction is influenced by their perceived usefulness of technology, as well as the availability of necessary resources and infrastructure. In the context of the present study, differences in school population may present varying instructional and resource-management considerations in the integration of EdTech tools. Regardless of school size, the effective use of educational technology requires adequate access to digital resources and the capacity to select and utilize tools that respond to learners' instructional needs.

The findings indicate that AI-powered tutors were more commonly used by the participating Science teachers than PhET Interactive Simulations. This suggests a greater adoption of AI-powered tools among the respondents, although both technologies were utilized to support Science instruction. Their utilization may be associated with the perceived convenience and instructional applications of AI-powered tools, particularly in assisting with lesson preparation, content delivery, and providing learning support. In contrast, the relatively lower utilization of PhET Interactive Simulations suggests an opportunity to further explore the factors that may influence teachers' adoption of simulation-based learning tools, such as familiarity, accessibility, availability of technological resources, and opportunities for professional development. These findings highlight the importance of promoting a wider range of EdTech tools in Science instruction to provide teachers with diverse technological options that address different instructional objectives and learners' needs.

The findings suggest that EdTech tools were evident in the planning stage of Science instruction but were not yet fully maximized by the respondents. The relatively higher mean for the use of QuillBot indicates that teachers more frequently utilized this tool to support students' Science writing tasks. In contrast, the lower mean for the integration of ChatGPT, Gemini, and Copilot suggests that these tools were less frequently incorporated into instructional planning. The possible reasons for this variation in utilization may be further explored through the qualitative findings.

The findings are consistent with the assertion of Arinto et al. (2020) that the adoption of emerging technologies in education continues to gain prominence worldwide. The moderate extent of EdTech tools implementation in Science classes indicates that teachers have begun integrating AI-powered technologies into their instructional planning, reflecting the growing recognition of AI's role in shaping future educational and workforce demands. The relatively higher utilization of AI tools such as Quillbot demonstrates teachers' willingness to leverage technology to enhance student learning, while the moderate rating for the use of generative AI platforms such as ChatGPT, Gemini, and Copilot suggests that the integration of more advanced AI technologies is still evolving. This finding implies that although AI adoption among teachers is progressing in line with global educational trends, further support and capacity-building initiatives are needed to facilitate more effective and purposeful integration of these technologies into classroom instruction.

The findings indicate that EdTech tools were moderate in extent in Science instruction, suggesting that teachers have incorporated educational technologies into their teaching practices, although the extent of utilization varies across instructional activities. The relatively higher mean for accommodating students' diverse learning styles and needs suggests that teachers utilize EdTech tools to provide varied learning experiences. However, the very low mean for the use of Google Expeditions and VR glasses indicates limited extent of implementation of immersive technologies, particularly in facilitating virtual field trips.

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This variation may reflect differences in the availability of technological resources, infrastructure, and teachers' familiarity with specific digital tools. Consequently, the findings highlight the importance of providing adequate technological resources and professional development opportunities to support the broader and more purposeful integration of EdTech tools in Science instruction.

The finding is consistent with Örnek (2025), who emphasized that the integration of AI in education can help teachers address individual learning needs, enhance student engagement, and promote inclusive learning environments. The highest-rated indicator in the present study, which concerns the use of EdTech tools to accommodate students' diverse learning styles and needs, highlights the potential of educational technologies to support differentiated instruction and provide more responsive learning experiences in Science education.

However, the overall moderate level of the extent of implementation and the absence of virtual reality-based tools such as Google Expeditions indicate that the full benefits of AI and advanced educational technologies described by Örnek (2025) have not yet been fully realized in the classroom. These findings imply that while teachers are leveraging accessible EdTech tools to foster inclusivity and engagement, additional resources, infrastructure, and professional development are necessary to maximize the transformative potential of AI and other emerging technologies in Science education.

The findings indicate that EdTech tools were moderate extent in terms of intervention and assessment, suggesting that digital technologies were incorporated into teachers' instructional practices, although their utilization varied across the indicators. The highest-rated indicator suggests that teachers more frequently encouraged students to use EdTech tools beyond the classroom to reinforce and deepen their understanding of Science concepts. In contrast, the lower mean for the integration of AI and AR tools in lesson planning and delivery indicates that this practice was less extensively implemented. The qualitative findings may provide further insights into the factors influencing teachers' utilization of these technologies.

The result aligns with the findings of Zafer et al. (2025), who emphasized that the use of digital tools enhances academic performance, improves assessment outcomes, and fosters collaboration and inquiry among students. The moderate level of extent of implementation of EdTech tools in terms of intervention and assessment suggests that Science teachers are already utilizing digital technologies to extend learning beyond the classroom, particularly by encouraging students to use EdTech tools for reinforcement of Science concepts. This practice reflects Zafer et al.'s (2025) assertion that digital tools can support deeper understanding and improved learning outcomes when applied consistently. However, the limited and non-consistent integration of advanced technologies such as AI and AR indicates that the full potential of these tools in improving assessment performance and promoting collaborative inquiry has not yet been maximized. This implies that while teachers are beginning to recognize and apply the benefits of digital tools in Science education, sustained investment in infrastructure, training, and professional development is necessary to strengthen their integration and fully realize their impact on student achievement and engagement.

The result suggests that EdTech tools are perceived as beneficial in promoting student engagement in science education however, their implications are viewed as moderate which shows that opportunities for further enhancement are necessary for its implementation based on the perception of both principals and science teacher respondents. Aside from this, the result implies that science teachers have appreciation with EdTech tools that provides support to student's independent learning which are also necessary for student's interest and participation during science classes. However, Google Expeditions obtained the lowest mean among the three indicators, although it was still perceived as moderately beneficial by many and was agreed by most respondents.

The result supports the findings of Aslam et al. (2020), who emphasized that the effective utilization of digital learning resources enhances student engagement and promotes personalized learning experiences. The respondents' assessment that EdTech tools are moderately beneficial in fostering engagement suggests

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that digital technologies, particularly AI-based feedback tools, help maintain students' interest and participation by providing immediate responses and individualized support. This aligns with the notion that technology-enhanced learning environments can make lessons more interactive and responsive to students' needs. Likewise, the findings are consistent with Långström et al. (2024), who highlighted the significant advantages of EdTech in STEM education, even in contexts where access to quality educational resources may be limited. The moderate benefit perceived by science teachers and principals indicates that EdTech tools contribute positively to science instruction by creating opportunities for more engaging and accessible learning experiences. However, the moderate rather than high level of benefit also suggests that the full potential of these technologies may depend on factors such as resource availability, teacher preparedness, and effective integration into classroom practices.

The data from the table suggests that respondents agree that they perceive that EdTech tools beneficial on student's academic achievement in science education which are can be said as moderately beneficial on the perspective of science teachers and administrators. In addition to this, the relatively high rating for Google Expeditions suggests that respondents perceived immersive and interactive technologies as potentially useful for supporting students' understanding and retention of science concepts. Meanwhile, the lower rating for PhET Simulations compared with the other indicators indicates that respondents agreed that they perceived this tool as somewhat less beneficial for achievement, although it remained within the moderately beneficial range. The reasons for this difference may be further examined through the qualitative findings.

The results of this study are consistent with Ajayei and Udeh (2023) who have found that immersive learning systems provide students with enhanced opportunities to engage with and experience science in a real-world context. The highest-rated indicator in Table 8 states that increased student interest and participation, due to the use of gamified/asynchronous interactive content, leads to greater student involvement and improved academic achievement. Therefore, both administrators and teachers acknowledge the positive effect of using gamified and asynchronous interactive digital resources to improve student academic performance in science. The literature supports this finding, as students who use immersive technology have greater opportunities to dynamically interact with scientific concepts and have improved comprehension and retention of those concepts.

The findings suggest that respondents generally recognized the potential of EdTech tools to support collaborative learning in Science education. The overall rating indicates a favorable perception of the contribution of educational technologies to student collaboration. However, the relatively lower ratings for the integration of AI and AR tools in developing problem-solving and critical-thinking skills and enhancing student motivation suggest that these applications may not be perceived as equally beneficial as other technology-supported practices. These findings highlight the importance of exploring how different EdTech tools can be purposefully integrated into Science instruction to promote collaboration, active participation, and meaningful learning experiences.

Comparing Tables 7-9, it shows that respondents do generally agreed that they perceive EdTech tools as beneficial across the different dimensions being examined in this study. Particularly in Table 9, it can be seen that the dimension labeled collaboration has the highest recorded overall mean of 3.51., which can be interpreted as highly beneficial as many respondents agreed to the statement. This was followed by achievement in Table 8 where the mean was 3.49 and engagement in Table 7 where the mean is 3.44 which can both has agree. Although the dimensions being measured fall under different verbal interpretations, it can be observed that their mean scores are close to each other. Cross-referencing Table 7 and 8 further shows that the perceived benefits of the same technology varied in the application of instruction. Overall, the findings indicate that Science teachers and school administrators perceived EdTech tools as beneficial in supporting student engagement, achievement, and collaboration in Science education. The results suggest that educational technologies offer opportunities to enrich learning experiences, provide immediate feedback, support differentiated instruction, and facilitate the development of students' scientific

understanding and skills. AI-powered tools were particularly recognized for their potential to support personalized learning and instructional planning, while immersive technologies, such as augmented and virtual reality, and simulation-based tools offered opportunities for interactive and experiential learning. Although the respondents generally viewed these technologies positively, the varying ratings across indicators suggest that their perceived benefits differ depending on their instructional applications. These findings underscore the importance of purposeful technology integration and continued support for teachers in maximizing the potential of diverse EdTech tools in Science instruction.

Furthermore, the absence of significant differences suggests that respondents from schools of different sizes reported relatively comparable levels of EdTech implementation across the dimensions examined. This finding underscores the importance of considering factors beyond school size, such as teachers' technological competence, access to reliable digital resources, institutional support, and opportunities for professional development. Although these factors were not directly examined in the present analysis, they may provide relevant considerations for understanding the implementation of EdTech tools across different school settings. Thus, strengthening teacher capacity and ensuring adequate technological support remain important in promoting the meaningful integration of technology into science education.

Findings are in line with the findings of Zulyusri et al. (2023) which identified challenges of integrating educational technology into STEM lessons. These include issues around the availability of technology or equipment, the digital competencies of educators, and the amount of training and support received by educators, whereby any of these barriers may impact the effective use of digital tools, and therefore cannot be specifically attributed to either the type of EdTech or the barriers to EdTech integration itself. Furthermore, a lack of significant difference in the amount of EdTech being used to teach science, regardless of the Integrative technology type, implies that the type of technology is not significantly determined by whether or not it is being used to maximum potential when delivering Science lessons. Therefore, differences between types of technology being used for teaching may not be able to be quantified based upon their type alone, and instead reflects a more significant impact from other factors, such as educator support and training and equitable access to tech resources, which results in educators using the various types of technology in a relatively uniform manner. It may also be concluded from the study's findings that while more advanced technologies are capable of being used to their full potential; if barriers to using EdTech in classrooms continue to provide limitations on educator training and support or the unequal access to technology in classrooms, all types of technologies will continue to be implemented with similar amounts.

The literature of Gligorea et al. (2023) and Långström et al. (2024) emphasizes that educational technology expands students' access to a wide range of learning resources, such as digital libraries, open educational materials, and online databases. This increased access allows learners to explore topics more deeply, engage in independent research, and develop higher-order thinking skills such as critical thinking and analysis.

Furthermore, the findings imply that the value of EdTech in Science education lies not merely in the type of technology used but in how it facilitates access to knowledge and supports deeper learning. Even with variations in tools or school characteristics, the ability of educational technology to enhance information access and promote critical thinking may lead to relatively uniform integration practices among educators.

The findings can be meaningfully linked to the literature of Zulyusri et al. (2023), which highlights several challenges in the application of educational technology in STEM education, including unequal access to technology, varying levels of digital literacy, and the need for adequate training and support. These challenges are described as systemic issues that can influence how effectively EdTech tools are utilized, regardless of the specific context of the school.

These findings are consistent with Haleem et al. (2022), who emphasized the importance of educators' knowledge, skills, and confidence, together with adequate training and institutional support, in facilitating successful technology integration. In this regard, the findings underscore the need for schools to strengthen teachers' technological competence and provide relevant professional development opportunities to support the purposeful integration of EdTech tools in science instruction. Providing adequate resources, technical assistance, and sustained instructional support may help teachers maximize the potential benefits of educational technologies in promoting student engagement, supporting academic learning, and facilitating collaboration.

The findings from the quantitative and qualitative phases of the study generally converge, as presented in the preceding table. Both datasets indicate that educational technology (EdTech) tools are already being utilized in science education, although their implementation has not yet been fully maximized. The quantitative findings revealed a moderate level of EdTech implementation, while the qualitative findings provided explanations for this result, identifying weak internet connectivity, limited availability of devices, insufficient professional development, and unequal student access to technology as major barriers.

Furthermore, the two datasets demonstrate complementarity in explaining the perceived benefits and conditions influencing EdTech integration. The quantitative findings indicated that EdTech tools contribute positively to student engagement, achievement, and collaboration. Meanwhile, the qualitative findings provided contextual insights into how these benefits are experienced and the conditions necessary to achieve them. For instance, although EdTech tools can enhance student participation, their effectiveness depends on students' access to digital devices, reliable internet connectivity, and appropriate teacher guidance.

However, a degree of divergence emerged regarding the use of AI-powered tools. While the quantitative findings indicated substantial utilization and perceived benefits of these tools, the qualitative findings revealed concerns about students' overdependence on AI, potential distractions, and difficulties in verifying the authenticity of students' work. These findings suggest that although AI-powered tools offer instructional benefits, their integration requires appropriate supervision and adherence to responsible and ethical practices.

Overall, the integrated findings indicate that EdTech integration in science education is established but remains at a developing stage. Although teachers recognize and utilize the instructional benefits of EdTech tools, their effective implementation is constrained by technological, institutional, and learner-related factors. Thus, successful EdTech integration requires not only the availability of digital tools but also reliable technological infrastructure, sustained professional development, equitable student access, and responsible use of AI-powered technologies.

Limitations

The purposive sample was limited to 32 respondents from nine private schools in two districts, with nine interview participants. The results describe reported practices and perceived benefits rather than independently measured student outcomes. The cross-sectional design does not establish causality. The small and uneven groups limit statistical power and generalizability. The reported statistical test labels and the benefit response anchors require confirmation against the original instrument and analysis output.

CONCLUSION

EdTech integration was moderate across planning, instruction, and intervention and assessment. Respondents perceived favorable benefits, particularly for collaboration. The reported comparisons identified significant differences in planning and instruction by location and in planning by tool type; other

comparisons were nonsignificant. These findings do not establish equivalence across groups. Teachers described persistent infrastructure, access, training, and responsible-use challenges alongside adaptive instructional practices. The proposed guidelines provide a context-specific basis for improving integration through equitable resources, professional development, and pedagogically purposeful and ethical technology use.

Recommendations

Based on the findings and conclusions of the study, the following recommendations are proposed:

1. Schools should promote the broader integration of AI-driven tools in science education while ensuring equitable access to supplementary digital learning resources, including interactive simulations, to enhance instructional practices and learning experiences.
2. Teachers should receive training and instructional guides on maximizing the use of EdTech tools in science instruction. These should include strategies for facilitating independent student exploration and virtual field trips.
3. Teachers may adopt structured approaches to incorporating gamified, interactive, and collaborative tools into their lessons. Clear guidelines should also be provided to prevent excessive reliance on AI and ensure that technology enhances rather than replaces critical thinking and active engagement.
4. School leaders and policymakers may prioritize improving teachers' digital literacy, access to appropriate technology, and opportunities for continuous professional development rather than treating geographical location, school size, or specific tools as limiting factors.
5. Schools should establish professional development programs and initiatives that strengthen teachers' pedagogical integration of technology, emphasizing best practices for student engagement, achievement, and collaboration across diverse educational contexts.
6. Policymakers and school leaders may prioritize improvements in technological infrastructure, internet connectivity, and equitable access to devices to address systemic barriers to EdTech integration. Comprehensive and continuous training in EdTech and AI utilization may also be implemented to strengthen teachers' confidence, proficiency, and ethical understanding while promoting responsible student engagement.
7. Schools and governing bodies may institutionalize teachers' adaptive strategies through formal policies, structured guidelines, and adequate resource provision. Long-term investment in EdTech resources, professional development, and clear guidelines for responsible AI use may support effective and sustainable technology integration in science education.
8. Schools may adopt the proposed guidelines to strengthen EdTech integration in science education through training, access to resources, and guidance on responsible AI use. These guidelines complement the recommendations by providing actionable steps, suggested activities, and monitoring strategies that teachers and administrators can follow to ensure consistent and meaningful technology integration in science classrooms.

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