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Technology Integration in Teaching Elementary Science, Adequacy of Instructional Materials and Development of 21st Century Skills: A Proposed Intervention Program

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ABSTRACT
This descriptive study examines the level of technology integration in elementary Science instruction, the adequacy of instructional materials, and the development of learners' 21st-century skills. Drawing on survey responses and interviews with Science teachers and learners in selected public elementary schools, the findings indicate that digital resources are frequently used to enhance lessons, particularly in support of inquiry-based learning. Teachers observed that such integration promotes student engagement and supports the development of critical thinking and creativity. However, challenges persist, including limited teacher proficiency in using technology for instructional delivery, inconsistent access to core learning materials such as textbooks and Science kits, and low learner performance in technological and information literacy. These barriers suggest gaps in infrastructure and professional development that hinder effective implementation. The study underscores the need for sustained investment in teacher training, access to essential learning tools, and the strategic use of educational technology to strengthen Science instruction and cultivate 21st-century competencies among learners.

KEYWORDS: instructional materials, science education, technology integration, 21st-century skills

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1. Introduction

Science education serves as a cornerstone for developing learners' curiosity, critical thinking, and understanding of the natural world. However, recent evaluations of Philippine science education have revealed concerning trends in the quality of instruction and student outcomes. According to the Southeast Asia Primary Learning Metrics (SEA-PLM), a significant number of Grade 5 Filipino students fall below the minimum proficiency levels in scientific inquiry and reasoning. These findings mirror earlier results from the 2019 Trends in International Mathematics and Science Study (TIMSS), where the Philippines ranked among the lowest-performing countries in Science, with many learners struggling to demonstrate even foundational skills (IEA, 2020). In the Baloi West District Schools, informal school-based assessments from the 2022–2023 academic year similarly revealed that a large proportion of elementary learners were underperforming in Science competencies, particularly in tasks requiring inquiry, analysis, and real-world application. These statistics point to an urgent need to enhance instructional strategies and learning environments in elementary Science education.

One instructional shift gaining recognition is the integration of educational technology, especially when combined with appropriate instructional materials and approaches that foster 21st-century skills. Research has shown that technology-enhanced learning environments can improve student engagement, promote inquiry-based learning, and support the development of critical skills such as creativity, communication, collaboration, and digital literacy (Calaguas, 2021; Cano & Peters, 2021). However, the use of technology in many public elementary schools remains inconsistent due to infrastructure limitations, insufficient digital content, and a lack of teacher training. Additionally, instructional materials are often outdated, overly textbook-dependent, or misaligned with the demands of 21st-century science education. These challenges not only hinder learner achievement but also widen the gap between educational goals and classroom realities.

Although existing literature affirms the benefits of technology integration and resource-rich instruction, most studies focus on urban, high-capacity schools or higher levels of education. There is limited research that captures the experiences of teachers and learners in under-resourced rural schools where systemic challenges persist. Studies by George and Wong (2021) and Lawrence et al. (2020) emphasize the need to examine how contextual factors such as teacher competence, material adequacy, and environmental support affect technology use and skill development in localized settings. In Baloi West District, little is known about how these factors interact in elementary Science classrooms or how they contribute to learners' acquisition of essential 21st-century competencies.

The purpose of this study is to determine the level of technology integration in teaching elementary science, assess the adequacy of instructional materials, and evaluate their relationship to the development of 21st-century skills among learners in Baloi West District Schools during the school year 2022–2023. By investigating how these variables influence each other, the study aims to offer evidence-based insights and practical recommendations that can inform school-level practices, teacher training, and instructional material development. The findings are expected to support efforts in enhancing elementary science education and ensuring learners are equipped with the competencies necessary to succeed in the digital age.

2. Methodology

This study employed a descriptive-correlational research design to examine the relationship between technology integration in teaching elementary Science, the adequacy of instructional materials, and the development of 21st-century skills among elementary learners in Baloi West District Schools. The chosen design allowed for the systematic collection of quantitative data to assess existing conditions, identify patterns of practice, and establish the extent of associations among the key variables in a real-world educational setting. This design was particularly suited for capturing both the measurable dimensions and contextual dynamics of teaching and learning within a rural public-school system (Alipio & Torres, 2023; Alipio et al., 2025; Torres et al., 2021).

The research was conducted in six public elementary schools under the supervision of the Department of Education within Baloi West District, located in the municipality of Baloi, Lanao del Norte. Baloi is a 3rd class municipality in Northern Mindanao with a population of 68,465, based on the 2020 census. The participating schools, Baloi Central Elementary School, Pacalundo Integrated School, Momungan Elementary School, Balut Elementary School, Daduan Elementary School, and Bangko Elementary School represent a range of contexts in terms of infrastructure, teacher experience, and access to educational technology. These schools were selected to provide a comprehensive overview of the varied conditions under which technology and instructional materials are utilized in Science education. The researcher, an in-service Science teacher within the district, had prior rapport with the school communities, facilitating smooth access, trust, and data collection.

Participants in the study included 60 elementary Science teachers and 60 learners purposively selected based on their direct involvement in teaching and learning activities that involved technology integration and instructional resource use. This purposive sampling ensured that only those familiar with the research variables were included. In addition, 10 school heads participated in semi-structured interviews to provide administrative and leadership perspectives, enriching the analysis through methodological triangulation. This approach aligned with the recommendations of Cresswell (2013), who advocates for mixed data sources to improve credibility and contextual understanding in educational research.

Data collection instruments consisted of structured survey questionnaires adapted from Ramaila and Molwele (2022), which were divided into three main sections: (1) technology integration in teaching Science, (2) adequacy of instructional materials, and (3) development of 21st-century skills among learners. Items were rated using a four-point Likert scale to capture participants' levels of agreement and observation. The questionnaire was reviewed by three educational experts for content validity prior to administration. To complement the survey data, a semi-structured interview guide was developed for school heads, allowing exploration of deeper institutional experiences with instructional resource management and technology adoption in Science education.

Ethical clearance was obtained from the Research Ethics Review Committee of Iligan Medical Center College, with subsequent endorsements from the Dean of the Graduate School. Written permissions were secured from the Schools Division Superintendent of Lanao del Norte and the principals of the participating schools. All participants received a written explanation of the study's purpose, procedures, and confidentiality provisions. Informed consent was obtained from all adult participants, and assent and parental consent were secured for learners. Participation was entirely voluntary, and anonymity was preserved in data reporting.

Quantitative data from surveys were analyzed using descriptive statistics, including weighted means to determine levels of technology integration, instructional material adequacy, and 21st-century skill development. Pearson's r correlation coefficient was employed to assess the strength and direction of relationships between the study variables.

3. Results and Discussion

Table 1. Level of technology integration in teaching elementary science.

Indicators	Mean	Interpretation
Integration of Digital Resources	3.38	True to me
Use of Technology in Delivering Instruction	3.03	True to me
Application of Technology for Facilitating Inquiry-Based Learning	3.22	True to me
Overall Mean	**3.21**	**True to me**

Presented in Table 1 is a summary of indicators on the level of technology integration in teaching elementary science, as reflected in the overall mean scores and their corresponding interpretations. As shown, the indicator "Integration of Digital Resources" registered the highest mean of 3.38, which is interpreted as "True to Me." This was followed by "Application of Technology for Facilitating Inquiry-Based Learning" with a mean of 3.22, and "Use of Technology in Delivering Instruction" with a mean of 3.03, both of which also fall under the same interpretation. The overall mean score of 3.21 suggests that teachers generally perceive themselves as practicing a moderate level of technology integration in their science instruction.

This implies that while teachers acknowledge incorporating digital resources and leveraging technology for inquiry-based approaches, the use of technology in delivering instruction still presents areas for growth. The results indicate a functional, yet not fully optimized, integration of technology in the classroom. Teachers may benefit from targeted training and support to improve instructional delivery using digital tools, which could help elevate the integration from a basic level to a more robust and transformative use of educational technology.

These findings align with the study of Akram et al. (2022), who emphasized that many teachers recognize the importance of technology integration but still face limitations in fully incorporating it into instructional delivery. Similarly, Yılmaz (2023) asserted that effective integration of technology in science education requires continuous professional development and access to quality resources to promote deeper learning and skill development. Furthermore, Kamarudin et al. (2024) highlighted that the success of technology integration depends largely on teachers' confidence, pedagogical knowledge, and availability of support mechanisms, especially in the context of inquiry-based science instruction.

Table 2. Assessment of the adequacy of instructional materials in teaching elementary science.

Indicators	Teachers	Interpretation	Learners	Interpretation
Availability of Science Textbooks and Supplementary Materials	1.72	Somewhat Adequate	1.70	Somewhat Adequate
Quality and Relevance of Instructional Materials	2.94	Adequate	3.39	Adequate
Variety of Instructional Materials Used	3.55	Highly Adequate	3.52	Highly Adequate
Overall Mean	**2.74**	**Adequate**	**2.87**	**Adequate**

Presented in Table 2 is the assessment of teachers and learners on the adequacy of instructional materials in elementary Science instruction, focusing on three aspects: availability, quality and relevance, and variety of materials. The overall means of teachers (Mean = 2.74) and learners (Mean = 2.87) indicate that instructional materials are generally "Adequate." However, both groups rated the availability of Science textbooks and supplementary materials as only "Somewhat Adequate" (Teachers = 1.72; Learners = 1.70), reflecting concerns about insufficient copies, irregular access, and distribution issues that limit effective classroom delivery. The quality and relevance of materials received "Adequate" ratings (Teachers = 2.94; Learners = 3.39), suggesting general alignment with the curriculum but highlighting the need for regular content updates to maintain relevance with current Science trends. Meanwhile, the highest ratings were observed for variety (Teachers = 3.55; Learners = 3.52), signifying that teachers utilize a diverse range of instructional tools—such as visuals, hands-on activities, and multimedia—to support different learning styles.

The qualitative data from interviews with school heads corroborate these findings. Most school heads confirmed that while Science textbooks provided by the Department of Education (DepEd) are available, supplementary materials remain scarce, particularly in less-resourced schools. P1 noted that “teachers have to rely on online resources or create their own materials,” while P4 emphasized that “Science kits or visual aids are scarce, which limits the depth of teaching.” In terms of quality and relevance, respondents acknowledged that textbooks are generally useful but often outdated or insufficiently engaging. As P3 explained, “The textbooks are good for basic learning, but they don’t always keep up with new trends in science or provide enough opportunities for interactive learning.” These perspectives indicate that although teachers maximize existing resources through creativity and innovation, systemic improvements in material provision and quality control remain necessary to ensure equitable and meaningful Science instruction.

The findings imply that the adequacy of instructional materials in Science instruction is moderately satisfactory but constrained by persistent issues in availability and consistency. Teachers’ initiative in using a wide range of materials demonstrates professional commitment and adaptability in addressing resource limitations. This result aligns with the findings of Ireen et al. (2024), who emphasized that well-developed instructional materials enhance learner engagement and content mastery. Similarly, Gizaw and Sota (2023) found that diverse and innovative resources significantly improve learners’ analytical and communication skills in science, while Mamba (2024) highlighted that adequate and up-to-date materials promote inquiry-based learning and collaboration among students. These scholarly perspectives affirm the present study’s conclusion that improving the accessibility, quality, and variety of instructional materials is essential in advancing Science learning and fostering 21st-century competencies among elementary learners.

Table 3. Level of development of 21st century skills among the elementary learners.

21st Century Skill	Mean	Interpretation
Technological Literacy	2.52	Developed
Inquiry and Research Skills	3.33	Developed
Creativity and Innovation	3.07	Developed
Information Literacy	2.65	Developed
Communication Skills	2.90	Developed
Overall Mean	**2.89**	**Developed**

Presented in Table 3 is a summary of the level of development of 21st-century skills among elementary learners, as indicated by the overall mean scores and their corresponding interpretations. Among the five indicators, “Inquiry and Research Skills” obtained the highest mean score of 3.33, interpreted as “Developed,” suggesting that learners are becoming proficient in exploring questions, gathering data, and drawing conclusions based on evidence. This is followed by “Creativity and Innovation” (M = 3.07) and “Communication Skills” (M = 2.90), which were also interpreted as “Developed.” The lowest mean score was observed in “Technological Literacy” (M =

2.52), though it still meets the threshold for the same interpretation. The overall mean score of 2.89 indicates that learners, in general, have a developed level of 21st-century skills.

This finding suggests that while learners demonstrate emerging competence across all skill domains, their technological literacy remains at the baseline level of development. This could reflect limited access to digital tools, insufficient integration of technology in classroom instruction, or a lack of hands-on exposure to digital platforms and applications. Nonetheless, the consistent development across domains signifies that learners are acquiring essential skills that support critical thinking, creativity, and effective communication hallmarks of 21st-century education.

This result is consistent with the findings of Zainil et al. (2023), who emphasized that the development of 21st century skills in elementary learners is strongly influenced by the instructional approaches and learning environments provided by schools. Similarly, Gafoor (2024) noted that effective instructional design, when aligned with inquiry-based and skill-oriented strategies, enables young learners to enhance their research, innovation, and communication capabilities. Furthermore, Kalyani (2024) emphasized the critical role of early exposure to technology and inquiry in fostering foundational digital and scientific skills, which are vital for learners to succeed in both academic and real-world contexts.

Table 4. Significant relationship between the development of 21st century skills among learners and level of technology integration in teaching elementary science.

Variables	r-value	p-value	Interpretation	Decision
Development of 21st century skills among learners and level of technology integration in teaching elementary Science	0.562	0.000	Significant	Reject H_{01}

Presented in Table 4 is the correlation analysis between the development of 21st-century skills among learners and the level of technology integration in teaching elementary Science. The result shows a correlation coefficient (r) of 0.562, indicating a moderate positive relationship between the two variables. The p-value of 0.000 is less than the 0.05 level of significance, suggesting that the relationship is statistically significant. As a result, the null hypothesis (Ho_1), which states that there is no significant relationship between the development of 21st-century skills and the level of technology integration in teaching Science, is rejected. This finding indicates that higher technology integration in science instruction corresponds to greater development of 21st-century skills among learners.

The findings imply that technology integration plays a vital role in promoting 21st-century learning competencies among elementary students. The use of digital tools, interactive platforms, and technology-enhanced lessons fosters critical thinking, collaboration, creativity, and innovation—skills that are essential in the modern learning environment. As technology becomes embedded in instructional processes, learners gain more opportunities for inquiry-based and project-based learning, enabling them to take ownership of their educational experiences. Furthermore, this significant relationship underscores the importance of equipping teachers with the necessary digital pedagogical competencies and providing adequate infrastructure and support to ensure effective technology utilization in science instruction.

This finding corresponds with the research of Voogt and Roblin (2012), who emphasized that technology serves as both a medium and a catalyst in developing higher-order thinking and innovation. Similarly, Kennedy and Lee (2018) found that technology-enriched instruction enhances learner engagement, creativity, and problem-solving ability in the Philippine context. The Department of Education's emphasis on ICT integration in the K to 12 curricula also reinforces the importance of using technology to prepare globally competitive learners. Collectively, these scholarly insights affirm that integrating technology effectively within science education is fundamental in advancing the development of 21st-century skills among elementary learners.

Table 5. Significant relationship between the development of 21st century skills among learners and the level of adequacy of instructional materials.

Variables	r-value	p-value	Interpretation	Decision
Development of 21st century skills and level of adequacy of instructional materials	0.510	0.000	Significant	Reject Ho_1

Presented in Table 5 is the correlation analysis between the development of 21st century skills among elementary learners and the level of adequacy of instructional materials. The result shows a correlation coefficient (r) of 0.510, indicating a moderate positive relationship between the two variables. The p-value of 0.000 is less than the 0.05 level of significance, suggesting that the relationship is statistically significant. As a result, the null hypothesis (Ho_1), which states that there is no significant relationship between the development of 21^{st}-century skills and the adequacy of instructional materials, is rejected.

The findings imply that a greater level of adequacy in instructional materials is associated with a higher level of 21st-century skill development among learners. Instructional materials that are adequate in quality, relevance, and accessibility contribute to more meaningful learning experiences. These resources support learners in practicing critical thinking, creativity, communication, technological literacy, and inquiry-based problem-solving skills that are essential in the 21st-century learning environment.

This finding corresponds with the research of Ireen et al. (2024), who emphasized that appropriate and well-developed instructional resources enhance learner engagement and foster the development of core competencies aligned with 21st century demands. Furthermore, Gizaw and Sota (2023) highlighted that access to varied and innovative teaching materials significantly improves students' communication and information processing skills, particularly in science education. In support of this, Mamba (2024) underscored that adequate instructional materials not only reinforce content mastery but also provide learners with opportunities to collaborate, inquire, and innovate in authentic learning contexts. These scholarly insights reinforce the present study's conclusion that instructional material adequacy plays a crucial role in advancing the 21st-century skills of elementary learners.

4. Conclusion

Based on the results of the study, it is concluded that technology integration, adequate instructional materials, and the development of 21st-century skills are moderately evident in elementary Science education. While teachers regularly use digital resources and varied instructional materials, limitations in infrastructure, access, and training hinder full integration. Learners show strengths in inquiry and creativity but need support in digital and information literacy. Strengthening teacher capacity, improving resource availability, and investing in infrastructure are essential to enhance Science instruction and foster 21st-century learning.

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Conflict of Interest Statement

The author declares no conflict of interest.

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