International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Integration of Augmented Reality in K-12 Classrooms for Science Education: Issues and Challenges

Sundayboy I. Maloloy-On [a], Crishia Mae B. Corpuz [b], And Arniel C. Diosmaparan [c]

[a] *Faculty of Industrial Technology Education, North Eastern Mindao State University, Philippines*
[a] *Faculty of Saint Michael College Inc., Cantilan,, Philippines*
[a] *Faculty of Saint Michael College Inc., Cantilan, Philippines*

A B S T R A C T

This study explored the lived experiences, issues, and challenges encountered by K–12 science teachers in integrating Augmented Reality (AR) into classroom instruction, with the goal of informing context-responsive strategies for effective AR adoption in Philippine science education. Specifically, it aimed to understand teachers' perceptions of AR, identify technical, pedagogical, and institutional barriers, and examine their coping mechanisms and proposed recommendations. A qualitative research design was employed using key informant interviews with ten science teachers from public schools in Surigao del Sur who had experimented with AR technologies in their instruction. Data were analyzed thematically to generate meaningful patterns based on their narratives. Findings revealed three major themes. First, science teachers expressed positive perceptions of AR, highlighting its ability to enhance engagement and improve conceptual understanding, particularly in abstract topics. However, cautious optimism was noted due to uncertainty about implementation, lack of training, and challenges in aligning AR with the curriculum. Second, teachers encountered multiple challenges such as poor internet connectivity, lack of compatible devices, insufficient pedagogical tools, and limited institutional support. Third, teachers demonstrated various coping strategies including the use of personal devices, collaboration with colleagues, and self-learning. They also recommended structured training, technical support, and access to AR-ready content. The study concluded that while AR held significant potential to enhance science instruction, its effective integration in K–12 classrooms required targeted support, professional development, and institutional alignment. It was recommended that future studies examine the impact of AR on student learning outcomes, develop contextualized teacher training models, and explore scalable implementation strategies to support the broader adoption of AR in Philippine education.

Keywords: Augmented Reality (AR), K–12 Science Education, Instructional Technology, Teacher Perceptions, Integration Challenges, Contextualized Learning, Educational Innovation

1. Introduction

The rapid development of digital technologies has transformed the landscape of education, enabling more immersive, interactive, and student-centered learning environments. Among these innovations, Augmented Reality (AR) has gained traction for its capacity to blend virtual content with the real world in real time, offering new pedagogical opportunities in science education. AR applications can visualize complex scientific phenomena such as atomic structures, biological processes, and planetary motion, which are otherwise difficult to represent using traditional resources (Fombona-Pascual et al., 2022). Merging tangible environments with computer-generated elements, AR helps learners conceptualize abstract ideas and promotes engagement, motivation, and experiential learning (AlGerafi et al., 2023).

In K–12 settings, AR has been shown to support constructivist and inquiry-based learning, making it a promising tool for science instruction. Intarapreecha and Sangsawang (2023) found that AR-enhanced instruction improves both academic performance and spatial ability among high school students. Similarly, Pani et al. (2025) demonstrate that AR fosters self-directed learning and enhances the retention of scientific knowledge. In the Philippines, where science education often faces challenges such as limited laboratory access and a lack of hands-on learning opportunities, AR has the potential to address instructional gaps by simulating real-world experiences in low-resource settings (Doncillo & Justo, 2025).

However, the actual integration of AR in K–12 classrooms remains limited and uneven. Teachers often encounter multiple barriers, such as insufficient training, limited access to AR-ready devices, lack of curriculum integration, and apprehension toward technology adoption (Fearne & Hook, 2023). The implementation of AR also requires a sound understanding of Technological Pedagogical Content Knowledge (TPACK), which many educators in public schools may not yet fully possess (Belda-Medina et al., 2022).

In the Philippine context, despite national efforts such as the DepEd Computerization Program (DCP) and the push for digital literacy under the K–12 curriculum, many schools—particularly those in rural and geographically isolated areas like Surigao del Sur—struggle with the foundational infrastructure needed to support AR-based instruction. Several public schools across the province continue to operate with limited access to stable internet, outdated computer equipment, and inconsistent electricity supply, making it difficult for science teachers to incorporate immersive digital tools into their lessons

(Basjan, 2024). In some coastal and upland barangays, teachers still rely heavily on printed modules and chalkboard instruction due to the lack of functioning projectors or AR-ready devices. Reports from local divisions have noted that even when tablets or laptops are provided, teachers receive minimal training on content-specific technology integration, particularly for science (Rice, 2023). Furthermore, with large class sizes, multi-grade teaching loads, and administrative tasks, teachers often prioritize curriculum delivery over innovation. These realities present a stark contrast to the high expectations placed on educators to innovate through ICT and highlight the gap between national policy and local implementation capacity.

In addition to structural and technical constraints, acceptability issues also hinder the successful integration of AR. Teachers' attitudes toward AR use are often shaped by their confidence in using technology, perceived usefulness, and relevance to the curriculum. Some educators express hesitation due to concerns about classroom management during tech-enhanced lessons, fears of device malfunction, or a belief that AR may complicate rather than simplify instruction (Smith, 2025). Without adequate orientation and pedagogical support, even well-resourced schools may face low adoption rates of AR despite its availability. These concerns underscore that the successful use of AR is not merely a matter of access, but also one of teacher readiness, mindset, and contextual fit.

Moreover, the literature reveals a gap in research that explores teachers' first-hand experiences and contextual challenges in adopting AR for science instruction. While most studies focus on student outcomes, very few examine the pedagogical, technical, and institutional barriers that teachers navigate in real-world classroom environments (Kumbo, 2023). Teachers' voices are crucial in understanding how educational technologies are perceived, adapted, or resisted in everyday practice. Without addressing these insights, interventions risk becoming disconnected from classroom realities. Given the growing emphasis on digital transformation in education and the evolving demands of 21st-century science teaching, it is essential to explore the real-world integration of AR in K–12 classrooms. While AR offers promising potential, its effective adoption depends on how well educators, institutions, and policies acknowledge and respond to the challenges that shape its acceptability.

This study, therefore, aims to examine the issues and challenges encountered by science teachers in using AR for classroom instruction. Specifically, it seeks to explore their lived experiences, identify key barriers, and surface their perceptions about AR integration. Through a qualitative lens, the research intends to inform future teacher training programs, improve ICT policies, and guide the development of AR-based innovations that are contextually responsive and pedagogically sound for Philippine science education.

1.1 General Objectives

To explore the lived experiences, issues, and challenges encountered by K–12 science teachers in integrating Augmented Reality (AR) into classroom instruction, with the aim of informing context-responsive strategies for effective AR adoption in Philippine science education. Specifically, this study sought to answer the following questions:

What are the perceptions of K–12 science teachers regarding the integration of Augmented Reality (AR) in classroom instruction?

What technical, pedagogical, and institutional challenges do science teachers in Surigao del Sur encounter in implementing AR in their classrooms?

How do science teachers cope with or address the challenges related to AR use, and what recommendations do they propose for improving its acceptability and integration?

2. Literature Review

The integration of Augmented Reality (AR) in education has grown rapidly in the past decade, driven by the need for more engaging, student-centered learning experiences. AR is defined as the overlaying of digital content—such as 3D models, text, or animations—onto the physical world, typically using smartphones, tablets, or head-mounted devices (Azuma, 2020; Dargan et al., 2023). In science education, AR holds particular promise because it helps learners visualize and interact with abstract or complex scientific concepts such as molecular structures, anatomy, or physics simulations (Hoai et al., 2024). Numerous studies confirm that AR can enhance students' motivation, improve retention, and foster inquiry-based learning, especially in STEM subjects (Wen et al., 2023).

In K–12 classrooms, AR-based learning environments support constructivist teaching approaches, where students actively engage with learning content in meaningful ways. For instance, Arici and Yilmaz (2023) both report that learners who used AR tools in science showed significantly better comprehension and problem-solving abilities compared to those in traditional instruction. Similarly, research by Wang et al. (2025) emphasizes that AR tools promote both spatial understanding and content mastery among high school learners. These findings are further supported by meta-analyses indicating that AR positively impacts academic performance, learner engagement, and collaborative learning, particularly when aligned with curricular goals (Lin and Yu, 2023).

Despite its potential, AR remains underutilized in actual school settings, especially in developing countries. In many K–12 contexts, the implementation of AR is still in its early stages, hindered by gaps in digital infrastructure, limited access to AR-compatible devices, and insufficient teacher preparation (Mustapha et al., 2024). Teachers often cite barriers such as the lack of technical support, slow or unreliable internet, and outdated hardware as major obstacles to technology-enhanced instruction (El Shafei, 2020). In low-resource areas, where classrooms lack even basic multimedia tools, the adoption of advanced tools like AR becomes more challenging and often unrealistic without external support (Ifenatoura, 2023).

Equally significant are the pedagogical challenges in integrating AR. Teachers must go beyond simply using technology—they need to align AR content with learning outcomes, manage student engagement, and evaluate learning effectively (AlGerafi et al., 2023). The Technological Pedagogical Content Knowledge (TPACK) framework has been widely used to assess teachers' ability to integrate technology into their instruction (Tseng et al., 2022). Studies show that many teachers are unfamiliar with AR as a teaching strategy and lack the training to apply it meaningfully in subject-specific contexts (Perifanou et al., 2022). In science instruction, where conceptual clarity and practical application are essential, AR use demands thoughtful lesson design and support.

The acceptability of AR integration also depends on teacher attitudes, beliefs, and confidence in using emerging technologies. Research grounded in the Technology Acceptance Model (TAM) shows that perceived usefulness and ease of use are key factors influencing teachers' willingness to adopt AR (Koutromanos et al., 2023). Educators who view AR as complex, unreliable, or disconnected from curriculum standards are less likely to experiment with it in the classroom (AlGerafi et al., 2023). Conversely, when teachers receive institutional support, professional development, and clear implementation frameworks, their openness to AR integration significantly increases (Mystakidis et al., 2021).

In the Philippine context, several challenges intersect to shape the acceptability and implementation of AR in science education. National initiatives such as the DepEd Computerization Program (DCP) aim to bridge the digital divide, but many rural schools—including those in Surigao del Sur—continue to face limitations in infrastructure, access, and technical support (Macale & Abante, 2024). Even when devices are provided, teachers often lack content-specific training and guidance on integrating AR into existing teaching plans. A study by Afutor (2020) found that while ICT tools are available in some public schools, only a small percentage of teachers use them regularly for science teaching, citing lack of training, curriculum misalignment, and workload as major factors.

Although prior studies confirm the positive effects of AR on learning outcomes, there is still a limited body of research that foregrounds the teacher's perspective, particularly in underrepresented regions like Mindanao. Most existing literature focuses on student performance or controlled pilot interventions, while the everyday challenges that educators face when adopting AR remain underexplored (Lampropoulos et al, 2022). Understanding teachers' lived experiences, contextual barriers, and adaptive strategies is vital to designing sustainable, context-appropriate interventions. This qualitative study therefore seeks to fill that gap by examining the issues, perceptions, and challenges of science teachers in Surigao del Sur who attempt—or choose not to attempt—to integrate AR into their instructional practices.

3. Methodology

3.1 Data and Source

This study employed a qualitative research design, specifically a phenomenological approach, to explore the lived experiences of K–12 science teachers in integrating Augmented Reality (AR) into classroom instruction. The phenomenological method was chosen to gain an in-depth understanding of how teachers perceived, accepted, and responded to the pedagogical, technical, and institutional challenges associated with AR use. This design was appropriate for capturing rich, descriptive accounts of participants' realities, beliefs, and practices in their educational contexts (Creswell & Poth, 2018).

3.2 Participants

The participants included public and private K–12 science teachers from selected schools in Surigao del Sur, Philippines, who had experience with or exposure to AR tools in the context of science teaching. A purposive sampling technique was used to identify participants who could provide relevant insights into the study. A total of 10 participants were targeted, depending on when data saturation was reached—the point at which no new information emerged. The inclusion criteria required participants to (1) have had at least one year of science teaching experience at the K–12 level and (2) have used, tested, or received training on AR-related instructional technology.

3.3 Instrument

The primary instrument for data collection was a semi-structured interview guide that the researcher developed and validated with the help of experts in educational technology. The guide contained open-ended questions designed to explore teachers' (1) perceptions of AR in science instruction, (2) challenges they encountered in its integration, and (3) coping strategies or support systems. Sample items included: "How did you perceive the potential of AR in teaching science?", "What challenges did you encounter or expect to encounter when using AR?", and "What support did you need to use AR effectively?" A pilot interview was conducted with one teacher outside the target group to refine the structure and wording of the questions.

3.4 Data Gathering Procedure

Before conducting interviews, the researcher sent formal letters to school heads requesting permission and secured informed consent from all participating teachers. Interviews were conducted either face-to-face or online via video conferencing platforms (e.g., Zoom or Google Meet), depending on participant accessibility. Each session lasted 30 to 45 minutes and was conducted in either English or Filipino, based on participant preference. All interviews were audio-recorded with consent, and the researcher took notes to document non-verbal cues and contextual details. The data collection process was completed within 3 to 4 weeks, and follow-up communications were used for clarification when needed. Ethical standards such as confidentiality, voluntary participation, and proper data handling were strictly observed.

3.5 Data Analysis

The researcher used thematic analysis following the framework of Braun and Clarke (2006). The steps included: (1) familiarizing with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. All interview recordings were transcribed, and the researcher read through the transcripts multiple times before assigning codes. To organize the data more efficiently, qualitative data analysis software (such as NVivo or Dedoose) was used. The researcher applied peer debriefing and member checking to ensure the credibility of the findings. Participants were asked to verify summaries of their responses to ensure accurate interpretation. Patterns across participants were compared to identify shared and contrasting perspectives.

4. Results and Discussions

Table 1: Perceptions of K-12 Science Teacher Regarding AR Integration

Themes	Actual Responses from Science Teachers (n=10)
Perceived Benefits	➢ "Mas dali nila masabtan ang abstract concepts basta makita nila in 3D gamit ang AR."
	➢ "Nag enjoy gyud ang mga bata. Dili sila katug og klase basta naa'y animation nga interactive."
	➢ "Makapadali sa pagtudlo, labi na sa mga topic nga lisod i-demonstrate."
	➢ "Sa solar system nga lesson, na-amaze sila. They were really focused and curious."
	➢ "AR helps to visualize things. Even ako, mas dali nako masabtan uban topics."
Cautious Optimism	➢ "Nindot siya tan-awon pero murag lisod gamiton pirme kay daghan kinahanglan."
	➢ "We want to explore it more, but we don't know how to start."
Need for Curriculum Integration	➢ "If naa sa MELC or lesson plan na nakaspecify ang AR, mas sayon siya i-justify gamiton."
	➢ "Wala mi materials or guide kung unsaon pag-align ang AR sa curriculum."
	➢ "Dili mi sure kung approved ba ni sa division or experiment lang ni namo."

Many science teachers shared positive experiences regarding the integration of Augmented Reality (AR) in their classrooms. Specifically, they highlighted that AR helped students understand abstract science concepts more easily, enhanced student engagement, and supported teachers in simplifying complex lessons. One teacher remarked, "Mas dali nila masabtan ang abstract concepts basta makita nila in 3D gamit ang AR", while another emphasized, "Nag enjoy gyud ang mga bata. Dili sila katug og klase basta naa'y animation nga interactive." This suggests that AR's immersive and visual features promote deeper engagement and better comprehension. Teachers also cited specific topics, such as the solar system, where AR had a significant impact on learners' curiosity and focus. However, despite these advantages, a sense of cautious optimism emerged. Teachers found AR promising but expressed hesitancy about its frequent use due to resource limitations and unfamiliarity. As one put it, "Nindot siya tan-awon pero murag lisod gamiton pirme kay daghan kinahanglan." Lastly, teachers pointed to the lack of curriculum alignment and official guidelines as a barrier, stating concerns like, "Wala mi materials or guide kung unsaon pag-align ang AR sa curriculum."

These findings align with several studies emphasizing AR's potential to transform science education by enhancing visualization, fostering engagement, and supporting active learning (Booyoesen, 2023). Research also affirms that AR can support the learning of abstract and complex scientific topics by presenting them in a more interactive and digestible format (Zhang & Wang, 2021). Moreover, AR's role in increasing motivation and curiosity has been highlighted in prior studies (Khan et al., 2019), which resonates with teachers' descriptions of student enthusiasm during lessons. However, similar to the present study, literature also notes significant barriers in AR implementation, particularly in resource-limited settings (Mondal & Mondal, 2025). The lack of technical training, instructional materials, and curriculum integration are consistent challenges faced by educators (Fasinro et al., 2024).

In contexts like Surigao del Sur, these barriers may be more pronounced due to infrastructure gaps and limited institutional support, reinforcing the cautious stance of teachers. The responses suggest that science teachers in Surigao del Sur view AR as an exciting instructional innovation with great promise, especially for improving students' understanding and engagement. However, their cautious stance reflects the systemic challenges they face—limited access to devices, poor internet connectivity, lack of AR-aligned curriculum guides, and uncertainty regarding policy support. Their need for official curriculum alignment and structured implementation reveals a disconnect between innovation and institutional readiness. This implies that while AR has strong potential as a pedagogical tool, its integration must be strategically planned. Capacity-building programs, clear instructional frameworks, and localized resources are needed to transform AR from an experimental tool into a regular teaching aid. More importantly, formal recognition and support from DepEd or the division level could enhance teacher confidence and ensure sustainable integration into science instruction.

Table 2: Technical, Pedagogical, and Institutional Challenges

Themes	Actual Responses from Science Teachers (n=10)
Technical Barriers	➢ "Usahay mo-off ang app kay hinay ang signal. Di mi ka-connect."
	➢ "Ang tablet nga gihatag, di compatible sa AR app. So among cellphone na lang gamiton."
	➢ "Wala mi projector or big screen. Ang bata maglinya-linya para lang kita sa screen."
	➢ "Sa upland school, wala gyud internet. So AR di gyud siya ma-apply ngadto."
Pedagogical Gaps	➢ "Wala mi formal training. Nag YouTube-YouTube ra ko unsaon paggamit."
	➢ "Even if I have the app, I don't know how to connect it with my lesson objectives."
	➢ "Wala mi evaluation tools kung effective ba ang paggamit sa AR."
Institutional Constraints	➢ "Limited support from the principal. Sila pud mismo wala kabalo unsa nang AR."
	➢ "Wala mi budget para tech tools. Gikan ra sa among kaugalingon."
	➢ "Among ICT coordinator busy pud. Di mi ma-accommodate tanan nga mangayo og tabang."

The teachers shared a range of challenges they encountered while trying to integrate Augmented Reality (AR) into classroom instruction. Under technical barriers, they pointed out issues such as poor internet connectivity, incompatibility of school-issued devices with AR applications, and limited hardware resources. One teacher mentioned, "Usahay mo-off ang app kay hinay ang signal. Di mi ka-connect," while another added, "Ang tablet nga gihatag, di compatible sa AR app. So among cellphone na lang gamiton." The lack of appropriate display equipment like projectors forced students to crowd around a single screen, as noted by a respondent: "Ang bata maglinya-linya para lang kita sa screen." This was even more problematic in upland schools with no internet access. In terms of pedagogical gaps, many admitted they had no formal training and had to rely on self-learning. As one put it, "Wala mi formal training. Nag YouTube-YouTube ra ko unsaon paggamit." Others expressed uncertainty in aligning AR with learning objectives and in assessing its effectiveness. Institutional constraints also surfaced strongly. Teachers cited a lack of administrative support, insufficient budget for AR tools, and limited technical assistance. Some shared that even school leaders lacked familiarity with AR, and ICT coordinators were overwhelmed with other tasks. A teacher stated, "Limited support from the principal. Sila pud mismo wala kabalo unsa nang AR." These challenges echo findings from previous research on AR integration in classrooms.

Studies have consistently shown that technical infrastructure, such as internet speed, device compatibility, and availability of hardware, plays a significant role in determining the feasibility of AR-based instruction (Qiao et al., 2019). In rural or underserved areas, these issues are often magnified due to budget limitations and connectivity gaps (Gwaka et al., 2023). The lack of teacher preparation in AR use is another common concern. Research has identified a need for professional development that covers both the technical use and pedagogical integration of AR tools (Mystakidis et al., 2021). Teachers who do not receive such training may struggle to link AR experiences to learning goals, which limits the tool's educational effectiveness. Institutional support is crucial in adopting new technology. Consistent with the present findings, Padgett (2025) found that teachers often lack administrative backing and are burdened by out-of-pocket expenses when implementing innovative strategies like AR. Without clear school policies, budget support, and designated ICT personnel, efforts to innovate often remain unsustained.

The results suggest that science teachers are enthusiastic about AR, but real-world constraints significantly hinder its implementation. Technological problems such as device incompatibility, poor connectivity, and lack of supporting equipment make it difficult for teachers to deliver AR-based lessons smoothly. Pedagogically, teachers feel underprepared and unsupported, highlighting the absence of structured training and classroom-based evaluation tools. Institutionally, teachers are often left to navigate AR integration alone. The lack of leadership involvement and budgetary allocation reveals a gap between technological ambition and administrative readiness. This signals an urgent need for a more systemic approach, where school heads, ICT coordinators, and education policymakers collaborate to create a conducive environment for AR adoption. Addressing these barriers means not just equipping schools with hardware and internet, but also investing in teacher capacity-building and providing policy guidance. Empowering educators with training, tools, and institutional backing will pave the way for AR to become a sustainable and meaningful part of science education in the Philippines.

Table 3: Coping Strategies and Recommendations

Themes	Actual Responses from Science Teachers (n=10)
Coping Mechanisms	➢ "Ako gamit akong kaugalingong phone, unya nag-download ko og free app."
	➢ "I borrowed my nephew's tablet just to try it in class."
	➢ "Nag-collaborate mi with TLE teacher para sa tech side. Nagtinabangay ra mi."
	➢ "Nag-print mi AR markers sa computer shop, kay wala mi printer sa school."
	➢ "Gipangutana nako akong anak kung unsaon kay sila kabalo na gamiton sa ilang school."
Recommendations	➢ "Mas maayo kung naa gyud structured training para teachers, dili lang orientation."

Themes	Actual Responses from Science Teachers (n=10)
	➢ "Dapat naay digital learning hub per district para maka-access mi ug AR-ready lessons."
	➢ "Hatagan ta og access sa curated AR content para sa K–12 science topics."
	➢ "Gusto unta mi og tech support staff nga mu-guide during implementation."
	➢ "Kung mahimo, himoan og pilot schools for AR use para makopya sa uban."

Despite various limitations in using Augmented Reality (AR) tools for science instruction, teachers have shown initiative in finding coping strategies to integrate the technology in their classrooms. A common response was the use of personal devices, as one teacher shared, "Ako gamit akong kaugalingong phone, unya nag-download ko og free app." Others resorted to borrowing gadgets: "I borrowed my nephew's tablet just to try it in class." Collaboration also emerged as a key coping mechanism. A teacher noted, "Nag-collaborate mi with TLE teacher para sa tech side. Nagtinabangay ra mi," while another found ways to generate resources: "Nag-print mi AR markers sa computer shop, kay wala mi printer sa school." Additionally, some teachers tapped into peer or family knowledge, saying, "Gipangutana nako akong anak kung unsaon kay sila kabalo na gamiton sa ilang school." For recommendations, teachers emphasized the need for more organized and sustainable support structures. They called for structured training programs rather than brief orientations, AR content hubs at the district level, and access to curated AR learning materials aligned with the K–12 science curriculum. One teacher suggested, "Mas maayo kung naa gyud structured training para teachers, dili lang orientation." Others expressed the need for technical assistance, saying, "Gusto unta mi og tech support staff nga mu-guide during implementation," and proposed the establishment of pilot schools to model AR integration.

The coping mechanisms highlighted by the teachers align with existing literature showing that, in resource-constrained settings, educators often rely on personal efforts and peer support to implement digital innovations (Nyongesa et al., 2025). Maya-Jariego et al. (2023) also showed that teachers commonly use own devices and informal networks to adapt new tools when institutional support is lacking. Collaborative practices, such as team teaching or cross-departmental support, have been identified as effective strategies for overcoming technical limitations (Hong, 2024). Seeking assistance from students or family, although informal, reflects a bottom-up innovation approach, where users drive the integration process themselves (Zorina, 2021). The recommendations shared echo calls in the literature for systemic teacher training and development of localized digital content Hardesty et al., 2020). The suggestion for pilot testing AR in selected schools aligns with best practices for educational technology adoption, ensuring context-sensitive implementation before wider rollout (Newman, 2025). Teachers are demonstrating resilience and resourcefulness in their efforts to use AR despite technical and institutional hurdles. These coping strategies, while commendable, highlight the lack of systemic support and structured infrastructure to enable widespread and sustainable AR use.

The dependence on personal devices and external help underscores the inequity in access and readiness among schools. The recommendations point to a clear demand for a more supportive ecosystem one that includes not only access to devices and internet, but also structured training, curated learning content, and designated technical support staff. Teachers are not simply requesting tools—they are seeking a long-term framework that makes AR integration feasible and effective. If education leaders act on these insights such as developing AR-ready learning hubs, assigning technical mentors, and institutionalizing pilot schools they can bridge the current implementation gap. This would empower more teachers to confidently integrate AR, ultimately enhancing engagement and comprehension in science education.

5. Conclusion and Recommendations

Integrating Augmented Reality (AR) into science education presents exciting opportunities for transforming traditional teaching into more interactive, immersive, and engaging learning experiences. In K–12 classrooms, especially in contexts where students struggle with abstract scientific concepts, AR has the potential to bridge gaps between theory and visualization. This study explored the perceptions, challenges, coping mechanisms, and recommendations of science teachers in the context of AR use in the Philippine basic education system, particularly within resource-limited school environments. The findings reveal that science teachers hold generally positive perceptions of AR technology. Many reported that AR enhances student understanding and engagement, particularly in lessons that are difficult to explain using traditional approaches. They observed improved attention and curiosity among learners when using interactive AR applications. These perceived benefits reflect the strong potential of AR to support meaningful and effective science instruction.

However, several issues hinder widespread AR integration. Teachers face technical challenges such as poor internet connectivity, incompatible or outdated devices, and the lack of infrastructure like projectors and screens. Pedagogical concerns were also raised, including the absence of structured training, limited knowledge on aligning AR with lesson objectives, and a lack of assessment tools to evaluate its effectiveness. On an institutional level, limited support from school leadership, budget constraints, and the unavailability of technical personnel further complicate the integration process.

Despite these challenges, science teachers continue to adopt creative coping mechanisms. They rely on personal devices, borrow equipment from family members, collaborate with colleagues, and seek out free AR resources and training materials online. These strategies show their resourcefulness and willingness to innovate in their teaching practices. They also expressed a clear desire for more support—structured training programs, access to curated AR content, and the establishment of digital learning hubs to facilitate implementation. Given these insights, future studies should focus on evaluating the actual impact of AR on student learning outcomes in science. Experimental or quasi-experimental designs can help assess its effectiveness in improving academic performance, retention, and engagement.

Researchers are also encouraged to explore scalable training models tailored for science teachers, such as modular or peer-led approaches. Furthermore, studies that investigate student perspectives can provide a more holistic understanding of AR integration. In addition, exploring the role of school leadership and policy support in AR adoption is crucial, especially in rural or low-resource areas. Long-term and comparative studies across different regions or school types may also reveal patterns and best practices for sustained and equitable implementation. By addressing these areas, future research can contribute to the development of a more supportive and inclusive educational environment where technology like AR can thrive.

Acknowledgements

The researchers sincerely thanks the science teachers from Surigao del Sur for sharing their valuable time and insights. Gratitude is also extended to school administrators for allowing the conduct of this study, and to the experts who helped validate the research tools. Appreciation goes to colleagues and mentors for their guidance, and to our family and friends for their constant support. Above all, thanks to the Almighty for the strength and wisdom throughout this research journey.

References

Afutor, P. (2020). ICT infrastructure, ICT competencies, and teachers' workload: Critical factors that influence social studies teachers' integration of technology in the Kwahu west municipality of Ghana. Journal of Education and Practice, 11(14), 65–75.

AlGerafi, M. A., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the potential: A comprehensive evaluation of augmented reality and virtual reality in education. Electronics, 12(18), 3953.

Arici, F., & Yilmaz, M. (2023). An examination of the effectiveness of problem-based learning method supported by augmented reality in science education. Journal of Computer Assisted Learning, 39(2), 446 – 476.

Basjan, S. H. (2024). A comparative study of principals' roles in the implementation of Information and Communication Technologies (Doctoral dissertation, University of the Free State).

Belda-Medina, J., & Calvo-Ferrer, J. R. (2022). Integrating augmented reality in language learning: Pre-service teachers' digital competence and attitudes through the TPACK framework. Education and Information Technologies, 27(9), 12123–12146.

Booyoesen, T. (2023). Exploring the impact of augmented reality on student engagement and learning outcomes in science education. Journal Educational Verkenning, 4(4), 25–32.

Dargan, S., Bansal, S., Kumar, M., Mittal, A., & Kumar, K. (2023). Augmented reality: A comprehensive review. Archives of Computational Methods in Engineering, 30(2), 1057–1080.

Doncillo, D., & Justo, A. (2025). Pedagogical Skills Through Laboratory-Based Instruction and Its Relations to the Current Status of the Science Laboratory Facilities. Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields, 1(7), 8–53.

El Shafei, R. A. (2020). Perceptions of teachers' regarding barriers to using instructional technology in Egyptian schools (Doctoral dissertation, Walden University).

Fasinro, K. S., Akinkuotu, F. A., & Aina, J. O. (2024). Curriculum Implementation: Challenges and the Prospect of Education Resource Centres to Aid Effective Implementation. African Educational Research Journal, 12(1), 1–5.

Fearne, W., & Hook, J. D. (2023). A service design thinking approach: What are the barriers and opportunities of using augmented reality for primary science education. Journal of Technology and Science Education, 329–251.

Fombona-Pascual, A., Fombona, J., & Vázquez-Cano, E. (2022). VR in chemistry, a review of scientific research on advanced atomic/molecular visualization. Chemistry Education Research and Practice, 23(2), 300–312.

Gwaka, L., Haseki, M., & Yoo, C. S. (2023). Community networks as models to address connectivity gaps in underserved communities. Information Development, 39(3), 524–538.

Hardesty, C., Moody, E. J., Kern, S., Warren, W., Cooley Hidecker, M. J., Wagner, S., ... & Root-Elledge, S. (2020). Enhancing professional development for educators: Adapting Project ECHO from health care to education. Rural Special Education Quarterly, 40(1), 42–52.

Hoai, V. T. T., Son, P. N., An, D. T. T., & Anh, N. V. (2024). An investigation into whether applying augmented reality (AR) in teaching chemistry enhances chemical cognitive ability. International Journal of Learning, Teaching and Educational Research, 23(4), 195–216.

Hong, M. (2024). Research on Management Mechanisms of Cross-Departmental Collaboration in Solving Complex Public Problems. Open Journal of Social Sciences, 12(12), 483–493.

Ifenatuora, G. P., Awoyemi, O., & Atobatele, F. A. (2023). Advances in Instructional Design for Experiential Mobile Classrooms in Resource-Constrained Environments. International Journal of Multidisciplinary Research and Growth Evaluation, 4(2), 773–778.

Intarapreecha, N., & Sangsawang, T. (2023). Incorporating augmented reality to enhance learning for students with learning disabilities: a focus on spatial orientation in physical. Journal of Applied Data Sciences, 4(3), 245 – 253.

Khan, T., Johnston, K., & Ophoff, J. (2019). The impact of an augmented reality application on learning motivation of students. Advances in Human-Computer Interaction, 2019(1), 7208494.

Koutromanos, G., Mikropoulos, A. T., Mavridis, D., & Christogiannis, C. (2024). The mobile augmented reality acceptance model for teachers and future teachers. Education and Information Technologies, 29(7), 7855–7893.

Kumbo, L. I., Mero, R. F., & Hayuma, B. J. (2023). Navigating the digital frontier: Innovative pedagogies for effective technology integration in education. The Journal of Informatics, 3(1), 14–33.

Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented reality and gamification in education: A systematic literature review of research, applications, and empirical studies. Applied Sciences, 12(13), 6809.

Lin, Y., & Yu, Z. (2023). A meta-analysis of the effects of augmented reality technologies in interactive learning environments (2012–2022). Computer Applications in Engineering Education, 31(4), 1111–1131.

Macale, R. J. S., & Abanto, R. G. (2024). Digitalization of DepEd Camarines Norte: Challenges and opportunities. International Journal of Open-Access, Interdisciplinary & New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR), 3(4).

Maya-Jariego, I., Holgado-Ramos, D., Santolaya, F., Villar-Onrubia, D., Cachia, R., Herrero, C., & Giannoutsou, N. (2023). Teachers' personal network analysis reveals two types of pioneers in educational digitalization: Formal and informal intermediaries at schools. Computers and Education Open, 4, 100137.

Mondal, H., & Mondal, S. (2025). Adopting augmented reality and virtual reality in medical education in resource-limited settings: constraints and the way forward. Advances in Physiology Education, 49(2), 503–507.

Mustapha, S. A. M., Zaharudin, R., Ariffin, H. F., & Abdullah, S. (2024). A systematic review exploring the impact of augmented reality on teaching modules in vocational education. Journal of Contemporary Social Science and Education Studies (JOCSSES), 4(3 Special Issue), 177–189.

Mystakidis, S., Fragkaki, M., & Filippousis, G. (2021). Ready teacher one: Virtual and augmented reality online professional development for K–12 school teachers. Computers, 10(10), 134.

Newman, C. (2025). From Exposure to Adoption: Investigating Perceptions of Augmented and Virtual Realities in Instructional Settings (Doctoral dissertation, University of Baltimore).

Nyongesa, J. W., & Van Der Westhuizen, J. (2025). Systematic literature review on balancing work-life integration for educators in online learning models in Africa. EUREKA: Social and Humanities, (4), 92–106.

Padgett, M. (2025). Factors Contributing to Teacher Attrition From the Perspectives of Teachers Who Left the Profession (Doctoral dissertation, Nova Southeastern University).

Pani, D., Maharana, N., Pradhan, S. K., & Das, S. (2025). Integrating Effect of AR and VR in Sustained Learning Outcomes in Self-Directed Learning Environments. In Impacts of AI on Students and Teachers in Education 5.0 (pp. 317–348). IGI Global Scientific Publishing.

Perifanou, M., Economides, A. A., & Nikou, S. A. (2022). Teachers' views on integrating augmented reality in education: Needs, opportunities, challenges and recommendations. Future Internet, 15(1), 20.

Qiao, X., Ren, P., Dustdar, S., Liu, L., Ma, H., & Chen, J. (2019). Web AR: A promising future for mobile augmented reality—State of the art, challenges, and insights. Proceedings of the IEEE, 107(4), 651–666.

Rice, J. M. (2023). Perceptions of Veteran Middle and High School STEM Teachers on Integrating Tablets into the Classroom (Doctoral dissertation, Walden University).

Smith, A. (2025). Generation Z Learners' Classroom Experiences in Surgical Technology Programs: A Descriptive Analysis (Doctoral dissertation, Capella University).

Tseng, J. J., Chai, C. S., Tan, L., & Park, M. (2022). A critical review of research on technological pedagogical and content knowledge (TPACK) in language teaching. Computer Assisted Language Learning, 35(4), 948–971.

Wang, L., Zhang, Q., & Sun, D. (2025). Exploring the impact of an augmented reality-integrated mathematics curriculum on students' spatial skills in elementary school. International Journal of Science and Mathematics Education, 23(2), 387–414.

Wen, Y., Wu, L., He, S., Ng, N. H. E., Teo, B. C., Looi, C. K., & Cai, Y. (2023). Integrating augmented reality into inquiry-based learning approach in primary science classrooms. Educational Technology Research and Development, 71(4), 1631–1651.

Zhang, W., & Wang, Z. (2021). Theory and practice of VR/AR in K-12 science education—a systematic review. Sustainability, 13(22), 12646.

Zorina, A., & Karanasios, S. (2021). When IT evolves beyond community needs: Coevolution of bottom-up IT innovation and communities. Journal of the Association for Information Systems, 22(4), 2.