



Bridging the Technology Practice Gap in Islamic Religious Education: A Qualitative Case Study of Teacher Adaptation

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ABSTRACT

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This study aims to examine the use of information technology (IT) in Islamic Religious Education (PAI) instruction, focusing on modes of utilization, implementation challenges, and teacher strategies. A qualitative case study design was employed at the school. Data were collected over three weeks through observations, semi-structured interviews with PAI teachers, the school principal, and students in grades VII–IX, as well as document analysis. Data analysis involved data condensation, data display, and conclusion drawing and verification, with credibility ensured through source and technique triangulation. Findings indicate that IT utilization primarily involves the use of laptops or computers, LCD projectors, PowerPoint, images, videos, and selective internet access. However, implementation remains heavily presentation-oriented due to equipment limitations, unstable power supply, connectivity issues, equipment malfunctions, unequal student access, and difficulties in managing digital materials. Teachers address these challenges through professional development, training, collaboration, technical preparation, and instructional adaptation. The study concludes that IT integration depends on infrastructure, teacher competence, accessibility, institutional support, and classroom conditions. These findings highlight the need for reliable infrastructure, continuous teacher development, and the integration of technology that is more interactive and student-centered.

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INTRODUCTION

The development of information technology has transformed the way people access, process, and use knowledge in everyday life, including in the field of education (Kirom, 2024; Nurhaeti, 2023). Technology no longer functions merely as a means of communication but has become part of the learning ecosystem that can expand access to learning resources, enrich the presentation of instructional materials, and enhance interaction between teachers and students (Aripin et al., 2025; Masdin et al., 2025). In education, the use of

technology has become increasingly important because students' characteristics and learning needs continue to evolve alongside the digital environment in which they live. Japar (2023) and Drouvelis (2023) demonstrate that technology can support more varied and interactive learning processes. Therefore, integrating technology into education is not merely a response to technological development but also a necessity for creating learning experiences that are relevant, adaptive, and responsive to students' needs.

Despite the opportunities offered by technology, its implementation in education is not always optimal. The problems faced by educational communities are not limited to the availability of technological devices but also involve teachers' ability to select, operate, and integrate technology according to instructional objectives (Magfiroh, 2026; Malla et al., 2023). The gap between technological availability and actual utilization may result in existing facilities failing to provide maximum educational benefits. In Islamic Religious Education (PAI), this issue becomes more complex because learning is not solely intended to improve students' knowledge but also to develop attitudes, moral character, and the practice of Islamic values. Consequently, the use of technology needs to remain aligned with the broader objectives of religious education. Fauzi (2026) and Asfiati (2023) emphasize that technology can support PAI learning when its use considers the objectives and distinctive characteristics of Islamic education.

This phenomenon can also be observed in PAI learning practices at SMP Tamansiswa Teluk Betung Utara. Preliminary observations indicated that the school has provided several information technology facilities, including computers or laptops, internet access, and LCD projectors. However, the availability of these facilities has not been fully accompanied by their intensive use in PAI instruction. Teachers still tend to rely on textbooks as the primary learning resources and use conventional tools such as whiteboards and markers to deliver instructional materials (Murhayati et al., 2026; Solong, 2024). LCD projectors are relatively infrequently used, while internet access has not been directly integrated into classroom learning and is more commonly used to search for information or supplementary materials outside the classroom. This condition indicates a gap between the availability of technological facilities and their actual utilization. These preliminary findings suggest that the integration of technology into PAI learning continues to face practical challenges that require further empirical investigation.

Previous studies have examined the use of technology in PAI learning from various perspectives. Rulitawati et al. (2025) for example, reported the use of Google Classroom, Zoom, Google Meet, YouTube, and other digital resources to support PAI and Islamic character education at SMA Negeri 1 Jember. Susanti et al. (2024) examined social media as a medium for PAI learning and found that its use could increase students' interest and participation. Utama et al. (2026) also

found a positive relationship between the use of information and communication technology and students' learning motivation, although challenges related to internet connectivity and limited facilities remained. These studies demonstrate the considerable pedagogical potential of technology. However, much of the existing research has focused on the benefits, forms of use, or effects of technology on particular educational outcomes, while the processes underlying the suboptimal utilization of technology in PAI learning remain insufficiently explored, particularly from the perspective of everyday classroom practice (Kurniawan et al., 2024; Lukman et al., 2024).

Previous research has also demonstrated that technology integration in Islamic education is influenced by multiple contextual factors. Rizkita et al. (2025) identified inadequate infrastructure, differences in user needs, and the need to align technology use with Islamic values as challenges in implementing technology in Islamic education. Batubara et al. (2025) and Fauzi et al. (2025) further highlighted the importance of teacher readiness, infrastructure conditions, and institutional support in determining technology utilization. Nevertheless, there remains limited research examining how these factors operate within actual PAI learning practices at the junior secondary school level, particularly in schools where technological facilities are available but have not been optimally utilized. Accordingly, the research gap addressed by this study concerns the need to understand the actual conditions of technology utilization, the supporting and inhibiting factors involved, and the strategies employed by teachers to address these challenges within a specific educational context.

The present study addresses this gap by connecting the availability of technology with its actual utilization in PAI learning. Its novelty does not merely lie in identifying the types of technologies used but in examining the gap between available facilities, the intensity of technology use, classroom conditions, and teachers' strategies for addressing implementation barriers. This perspective is important because the presence of technological devices in schools does not automatically indicate meaningful technology integration into teaching and learning. The study also focuses specifically on the junior secondary school context of SMP Tamansiswa Teluk Betung Utara, where technological facilities are available but their use in PAI learning remains limited. By examining this context, the study seeks to provide a more nuanced understanding of the contextual factors that shape technology utilization and to offer empirical insights for developing technology integration strategies that are realistic, context-sensitive, and responsive to the needs of teachers and schools.

Based on the preceding discussion, the central research problem concerns how information technology is utilized in PAI learning when technological facilities are available but their use remains suboptimal. This issue is important because limited technology utilization may result from multiple conditions

related to teachers, infrastructure, institutional support, and the characteristics of the learning process. Conceptually, this study argues that optimizing technology use cannot be achieved merely by providing technological devices; rather, it requires alignment among technology, teacher competence, instructional objectives, and the broader school environment. Therefore, this study aims to analyze the forms of information technology utilization in PAI learning, identify the supporting and inhibiting factors, and describe the solutions implemented by teachers to address the challenges encountered. The findings are expected to provide empirical evidence regarding technology utilization in PAI learning and contribute practical insights for developing more adaptive, contextually appropriate, and technologically responsive PAI instruction.

RESEARCH METHODS

This study employed a qualitative approach using a case study design to obtain an in-depth understanding of information technology (IT) utilization in Islamic Religious Education (PAI) learning at SMP Tamansiswa Teluk Betung Utara. A case study was selected because the study focused on examining a contemporary educational phenomenon within its real-life context, particularly the actual practices, experiences, supporting factors, barriers, and strategies associated with IT utilization in PAI learning. The study was conducted purposively at SMP Tamansiswa Teluk Betung Utara, Bandar Lampung, because the school has technological facilities, including computers or laptops, internet access, and LCD projectors, but their utilization in PAI learning was identified as not yet optimal. The research participants consisted of one PAI teacher, Ki. Hanafi, S.Pd., the principal, and students from Grades VII, VIII, and IX. Data collection was conducted over three weeks to capture the implementation of IT-supported PAI learning in its natural educational setting.

Data were collected through observation, semi-structured interviews, and documentation. Observation was conducted during PAI learning sessions to examine the use of information technology, the interaction between teachers and students during technology-supported activities, the integration of technological devices into the learning process, and the conditions that supported or constrained their use. Semi-structured interviews were conducted with the PAI teacher, principal, and students from Grades VII–IX to explore their experiences, perceptions, practices, challenges, and strategies related to the use of information technology in PAI learning. Documentation was used to complement the observational and interview data through relevant school records, lesson materials, photographs, and other documents related to technology-supported PAI learning. The combination of these data collection techniques enabled the researcher to obtain comprehensive information and cross-check findings from different sources and forms of evidence.

Data analysis followed an iterative qualitative process involving data condensation, data display, and conclusion drawing and verification (Mero et al., 2022; Monaro et al., 2022). Data condensation was conducted by selecting, organizing, coding, and focusing the observational, interview, and documentary data according to the research objectives, particularly the forms of IT utilization, supporting factors, inhibiting factors, and teachers' strategies for addressing barriers. The condensed data were then displayed in narrative descriptions and thematic categories to identify patterns and relationships among the findings. Conclusions were subsequently drawn by interpreting the emerging patterns and continuously verifying them against the available evidence throughout the research process. Data trustworthiness was established through source and technique triangulation by comparing information obtained from the PAI teacher, principal, and students and by cross-checking observations, interview statements, and documentary evidence. This process was used to assess the consistency, credibility, and confirmability of the findings.

RESULTS AND DISCUSSION

Results

Information Technology Integration in IRE Learning

In this study, information technology (IT) utilization is operationally defined as the use of technological devices and digital resources available at SMP Tamansiswa Teluk Betung to support Islamic Religious Education (PAI) learning, particularly in delivering instructional materials and providing learning experiences. The utilization primarily involved laptops or computers, LCD projectors, and internet access. Laptops or computers were used to prepare and store instructional materials, images, and videos, while LCD projectors were used to display materials visually. Internet access was used selectively, mainly to search for instructional materials before learning activities. Interviews with the principal indicated that the school had provided computers/laptops, LCD projectors in each classroom, a computer laboratory, and digital communication applications such as WhatsApp, Facebook, and Telegram. These facilities indicate institutional readiness to support technology integration, although their availability did not necessarily correspond to intensive classroom use.

The PAI teacher explained that computers or laptops connected to LCD projectors were used to present materials through PowerPoint, Microsoft Word, and instructional videos. Technology was also considered useful for reducing students' boredom because conventional lecture-based learning was dominant. These findings indicate that technology primarily functioned as a supporting medium for visual presentation and material delivery rather than replacing the teacher or transforming learning into a fully digital environment. Observations confirmed that technology use remained relatively simple. The teacher used

laptops or computers and LCD projectors to present PowerPoint materials, images, and photographs obtained from the internet, while explanations continued to rely mainly on lecture-based instruction. LCD use remained limited, and direct internet access during lessons was restricted because students were generally not permitted to use smartphones without permission.

Overall, IT had become part of PAI learning, but its utilization remained selective and had not fully exploited the available technological potential. Three main patterns emerged: a gap between infrastructure readiness and utilization intensity, a dominant orientation toward visual and presentational functions, and restricted classroom internet use. Laptops or computers and LCD projectors were primarily used to present instructional materials, images, and videos, whereas internet access was more commonly used for preparing materials before lessons or completing assignments outside the classroom. These findings indicate that IT integration was shaped not only by technological availability but also by pedagogical purposes, school policies, instructional practices, and classroom conditions. Thus, technology functioned primarily as a pedagogical support tool rather than as a fully integrated digital learning environment.

Table 1. Information Technology Utilization in PAI Learning

Informant Position	Sub-Finding	Indicator
Principal	The school provides computers/laptops, LCD projectors, a computer laboratory, and digital communication applications to support educational activities.	Availability of IT infrastructure
Principal	Information technology is perceived as supporting the development and quality of classroom learning.	Institutional perception of IT benefits
PAI Teacher	Computers/laptops connected to LCD projectors are used to present instructional materials, images, and videos related to PAI topics.	Digital instructional presentation
PAI Teacher	Technology is used to provide visual materials intended to reduce students' boredom and support their understanding of learning materials.	Visual learning support
PAI Teacher	Internet use during classroom learning is limited because students are generally not permitted to use smartphones during lessons.	Limited classroom internet access

Table 1 shows that the use of information technology in Islamic Religious Education (PAI) instruction at SMP Tamansiswa Teluk Betung is characterized by the availability of institutional infrastructure alongside the selective use of technology in the classroom. At the institutional level, the school has provided various technological facilities, including computers or laptops, LCD projectors, and a computer laboratory. These facilities demonstrate that the school has

established the basic infrastructure necessary to support technology integration. However, findings at the classroom level reveal that the available technology is not utilized uniformly. Laptops or computers and LCD projectors are frequently incorporated into PAI lessons—primarily to present instructional material visually whereas internet access plays a more limited role. Thus, these findings highlight a disparity between technological readiness at the school level and the intensity of technology usage at the classroom level.

These sub-findings further indicate that the dominant function of the technology is instructional and presentational rather than interactive. The use of PowerPoint, images, and videos enables teachers to provide visual representations of PAI lesson content and serves as a supplementary medium for explaining concepts. At the same time, the persistent use of lecture-based instruction suggests that technology has been integrated into existing teaching approaches rather than fundamentally transforming the pedagogical model. Limited internet usage reinforces this pattern, as students have restricted access to smartphones during class activities. Consequently, technology functions primarily as a teacher-controlled resource for delivering and illustrating lesson content, while opportunities for students to independently explore digital resources or engage in technology-mediated interactions remain limited.

Challenges in the Utilization of Information Technology in IRE Learning

Challenges in utilizing information technology in Islamic Religious Education (IRE) learning are operationally defined as various technical, infrastructural, and device-related conditions that hinder teachers from integrating technology into the learning process. Based on the field findings, these challenges were mainly associated with the use of computers/laptops and LCD projectors. In the use of computers or laptops, the challenges included incompatible connection cables, limited availability of devices for teachers and students, restricted access to the computer laboratory, and difficulties in locating relevant digital learning files. Meanwhile, the use of LCD projectors was constrained by electricity interruptions, connection problems with laptops, device malfunctions, and unclear or unfocused projection displays. Thus, the challenges were not limited to the availability of technological devices but also involved the technical readiness, accessibility, and usability of those devices during IRE learning.

The interview findings with the IRE teacher indicated that the limited availability of computers and laptops constituted one of the major challenges in implementing technology-supported learning. The school had not provided computers or laptops specifically for IRE learning in the classroom. Instead, computer facilities were concentrated in the computer laboratory, which had to be shared with teachers of other subjects. This condition limited the flexibility of

technology use according to the instructional needs of IRE teachers. When students were asked to bring and use their own laptops, another problem emerged because not all students owned laptops or had devices in adequate condition. This finding indicates that the device-related challenge was both structural and individual: at the school level, the availability of devices was limited, while at the student level, ownership and device quality were uneven.

The interview findings also indicated challenges related to the management of digital learning materials. When using computers or laptops, the teacher sometimes experienced difficulties because a large number of files related to learning materials were stored on the device, making it difficult to identify the appropriate file for the topic being taught. This finding suggests that the challenge of technology utilization extends beyond hardware availability to the management and organization of digital learning resources. A large number of unorganized files may increase preparation time and reduce the efficiency of technology use. Therefore, teachers' readiness to utilize technology also involves the ability to organize, identify, and select digital materials that are relevant to the learning objectives of IRE.

The observation findings showed that the most visible technical challenges occurred during the actual use of laptops and LCD projectors in the classroom. In several classrooms, electricity supply was interrupted, requiring the teacher to select a classroom with a functioning electrical connection to operate the laptop. This condition even resulted in students changing or exchanging classrooms so that the IRE lesson could continue with technological support. The use of LCD projectors also involved several technical problems, including devices that could not be turned on, difficulties connecting the projector to the laptop, and unfocused projection displays that caused images or textual information to appear blurred and difficult for students sitting at the back of the classroom to see. These observations indicate that technical disruptions can affect the continuity of learning because teachers have to allocate instructional time to adjusting or troubleshooting technological equipment.

Overall, the research data indicate that the challenges in utilizing information technology in IRE learning were not caused solely by limited facilities but resulted from a combination of device availability, infrastructure instability, connectivity problems, and digital learning-material management. Computers and laptops were constrained by availability, ownership, device condition, and file management, whereas LCD projectors were affected by electricity supply, connectivity, device condition, and display quality. Therefore, technology-related challenges in IRE learning can be understood as a gap between the technological requirements of learning and the technical readiness of the available facilities. The presence of technological devices does not automatically ensure that technology can be used smoothly, consistently, and sustainably in the learning process.

The data revealed four major patterns: limited device access, infrastructure disruption, operational difficulties, and reduced continuity of technology-supported learning. Limited device access was reflected in the absence of computers or laptops specifically allocated for IRE learning and the unequal ownership of laptops among students. Infrastructure disruption was evident in electricity problems and limited access to the computer laboratory. Operational difficulties emerged through incompatible cables, problems connecting the LCD projector to laptops, difficulties locating learning files, and unfocused projector displays. This pattern demonstrates that technology-related challenges occur at multiple levels, beginning with the availability of facilities and continuing through their actual use in classroom instruction. Consequently, effective utilization of information technology in IRE learning depends on the readiness of the supporting ecosystem rather than on the mere presence of technological devices.

Strategies for Overcoming Technology Utilization Challenges

Solutions for addressing challenges in the utilization of information technology in Islamic Religious Education (IRE) are operationally defined as the strategies undertaken by teachers to maintain and improve the use of technological devices despite technical, infrastructural, and competency-related constraints. Based on the field findings, these solutions included adapting teaching methods to the technological media being used, providing guidance and motivation to students, learning independently to improve technological competence, participating in technology-related seminars and training, reading relevant books and journals, conducting classroom-based inquiry, and discussing technological problems with fellow teachers. At the operational level, teachers also responded to specific problems by bringing their own laptops, storing learning materials on flash drives, seeking assistance when LCD projectors malfunctioned, and temporarily shifting to conventional teaching when electricity or projection equipment could not be used.

The interview findings indicated that teachers responded to technological challenges by continuously developing their own technological competence. The IRE teacher reported engaging in independent learning through regular use of laptops and computers, participating in seminars related to technology-supported learning, reading journals and books, and conducting inquiries into problems arising from technology utilization. The teacher also identified school-based training organized by the principal as an important opportunity for improving information technology competence. This finding indicates that teachers did not respond to technological constraints solely by relying on existing school facilities, but also attempted to strengthen their own capacity to use technology. The researcher interprets this as a form of teacher self-development

and professional adaptation, in which technological competence is developed through both individual initiative and institutional training.

Another interview finding showed that collaboration among teachers was used as a practical strategy for addressing problems encountered during technology-supported learning. Teachers reported discussing technological difficulties with colleagues, learning from other teachers, attending technology-related seminars, reading relevant resources, and conducting classroom-based investigations to identify better ways of utilizing technology in learning. The researcher interprets this finding as indicating that problem-solving was not entirely individual in nature. Instead, teachers developed a collaborative support mechanism in which professional discussion and shared experience became resources for overcoming technological difficulties. Such collaboration also enabled teachers to identify alternative strategies when a particular technological device or method could not be used as initially planned.

The observation findings showed that teachers applied different solutions according to the type of technological problem encountered. When computers or laptops were unavailable or insufficient, teachers brought their own laptops for classroom use and stored learning materials on flash drives so that files could be accessed more quickly during lessons. When LCD projectors experienced technical problems, teachers sought assistance from students or discussed the problem with other teachers, particularly when the projector could not connect to the laptop. When electricity was unavailable and the LCD projector could not be operated, teachers shifted temporarily to conventional instructional methods. Meanwhile, internet use was adapted to the school's classroom conditions by assigning students to search for relevant learning materials at home. These observations indicate that teachers responded to technological constraints through adaptation, assistance-seeking, resource preparation, and instructional substitution rather than abandoning the learning objectives.

The research findings can therefore be restated as follows: teachers employed two broad forms of solutions to address challenges in technology utilization. The first involved preventive and developmental strategies, including independent learning, seminars, training, reading academic and technological resources, professional discussion, and classroom-based inquiry. The second involved situational and technical strategies, including bringing personal laptops, preparing learning materials on flash drives, seeking assistance when devices malfunctioned, and switching to conventional teaching when technology could not be used. These strategies demonstrate that teachers attempted to maintain the continuity of IRE learning by adjusting both their technological practices and instructional methods to the conditions available in the classroom.

The data revealed a pattern of professional development, collaborative problem-solving, technical adaptation, and instructional adjustment. The pattern began with teachers' efforts to improve their technological competence through self-directed learning and formal training. When problems occurred during implementation, teachers relied on collaboration with colleagues and assistance from students. At the technical level, teachers prepared alternative resources such as personal laptops and flash drives, while at the instructional level, they adjusted teaching methods or temporarily returned to conventional instruction when technological facilities were unavailable. This pattern indicates that the teachers' response to technological challenges was adaptive rather than dependent on a single solution. The utilization of information technology was therefore maintained through a combination of teacher competence, professional collaboration, technical preparation, and pedagogical flexibility.

Discussion

The findings of this study show that information technology at SMP Tamansiswa Teluk Betung has been integrated into Islamic Religious Education (IRE) learning, particularly through laptops/computers, LCD projectors, PowerPoint, images, and videos. This finding is consistent with Parinduri & Ibarra (2025) view that ICT-based media can support IRE through visual, audiovisual, computer, and internet-based resources. The findings also correspond with Batubara et al. (2025) discussion of ICT use in education, particularly the use of PowerPoint and internet applications as learning media and resources. However, this study identifies a more limited level of implementation: technology primarily supports teacher presentations, while direct internet use, student exploration, and technology-mediated interaction remain restricted. This distinction suggests that infrastructure availability does not necessarily translate into intensive pedagogical integration (Hafiz et al., 2024; Baharun et al., 2025).

The study further found that the utilization of technology was constrained by limited devices, unstable electricity, connection problems, LCD malfunctions, unequal student access to laptops, and difficulties managing digital files (Parinduri & Ibarra, 2025; Rahmah et al., 2025). These findings are consistent with research emphasizing that teachers' ICT competence involves not only operating technological devices but also designing learning materials and applying appropriate methods in classroom contexts. Batubara et al. (2025), for example, identifies device mastery, ICT-based instructional-material development, and classroom application as important dimensions of teacher ICT competence. The present findings extend this perspective by showing that technological implementation is also shaped by institutional infrastructure and classroom conditions. The observed gap between available facilities and actual utilization

indicates that technological readiness should be understood as a combination of infrastructure, teacher competence, accessibility, and operational reliability rather than hardware provision alone.

Another important finding concerns the strategies developed by teachers to overcome technological constraints. Teachers engaged in independent learning, seminars, training, reading technological resources, professional discussion, and classroom-based inquiry, while also using personal laptops, flash drives, peer assistance, and temporary conventional teaching when technology failed (Abdullah, 2025; Ilmi, 2024; Rozi et al., 2025). This finding is compatible with literature emphasizing the importance of developing teachers' technological competencies through continuous professional development. Batubara et al. (2025) work similarly highlights the need to strengthen teachers' mastery of ICT devices, instructional-material development, and classroom application. The present study contributes a contextual perspective by demonstrating how such competence operates as an adaptive capacity in actual IRE classrooms. Rather than treating technology competence solely as technical mastery, the findings indicate that teachers' ability to adjust methods and mobilize alternative resources is equally important for sustaining learning when technological conditions are unstable.

Theoretically, these findings suggest that technology integration in IRE learning should be viewed as a context-dependent pedagogical process, rather than simply as the adoption of technological devices (Febrita et al., 2026; Hakim & Mu'id, 2025). The study demonstrates three interconnected dimensions: technological availability, pedagogical utilization, and adaptive teacher practice. This extends the conventional understanding of ICT integration represented by the use of computers, presentation software, and internet resources by showing that the effectiveness of integration is also mediated by institutional policies, infrastructure, teacher decisions, and classroom realities (Christina & Indra, 2025; Fahriansyah et al., 2025; Saleh et al., 2025). Nurhaeti (2023) emphasizes the potential of ICT to make IRE learning more varied and innovative, including through internet-based resources. In contrast, the present study shows that such potential may remain only partially realized when classroom access and infrastructure are constrained.

Practically, the findings imply that schools should not focus solely on procuring technological devices but should also strengthen infrastructure reliability, device compatibility, maintenance systems, digital-resource organization, and continuous teacher training. The contribution of this study lies in illustrating the relationship between technology availability, implementation barriers, and teacher adaptation specifically within IRE learning at the junior-secondary school level. The findings provide evidence that teachers can maintain instructional continuity through professional development, collaboration,

technical preparation, and pedagogical flexibility, even when technological resources are imperfect. At the same time, the study indicates that these individual adaptations should be complemented by institutional support so that technology use can gradually move beyond presentation-oriented practices toward more varied, interactive, and student-centered learning experiences.

CONCLUSION

This study concludes that information technology has become a supporting component of Islamic Religious Education (IRE) learning at SMP Tamansiswa Teluk Betung, particularly through the use of laptops or computers, LCD projectors, PowerPoint, images, and videos. The main lesson from the findings is that the availability of technological infrastructure does not automatically result in intensive or transformative technology integration; effective utilization depends on infrastructure reliability, accessibility, teacher competence, pedagogical decisions, and classroom conditions. The strength of this study lies in its contribution to understanding technology integration in IRE as a context-dependent and adaptive pedagogical process, highlighting how teachers combine professional development, collaboration, technical preparation, and instructional flexibility to sustain learning despite technological constraints. However, this study is limited by its focus on a single school and IRE learning context, which limits the transferability of the findings to other educational settings. Future research should therefore involve multiple schools with diverse technological conditions and examine how technology can be utilized beyond presentation-oriented practices toward more interactive, exploratory, and student-centered IRE learning.

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