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Bridging the Digital Divide: Technology Adaptation in Elementary Schools during the COVID-19 Pandemic in Remote Areas

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Abstract: This study explores the adaptation of technology in elementary schools during the COVID-19 pandemic, particularly in schools that had never implemented online learning before. The research focuses on SDN 216 Sondariah, a school in a remote area that faced significant challenges in transitioning to digital education. The study identifies key obstacles, including limited access to devices, poor internet connectivity, and the lack of digital literacy among both teachers and students. Despite these barriers, the school successfully utilized platforms like WhatsApp, Zoom, and Google Meet to facilitate communication and learning, although the effectiveness of these tools was hindered by infrastructure issues. The research highlights the impact of technology on improving literacy and numeracy, as well as the need for ongoing teacher training and infrastructure development. The findings suggest that sustained investment in digital literacy and infrastructure is crucial for the long-term success of digital learning, particularly in remote schools. This study contributes to understanding how technology can bridge educational gaps and offers recommendations for enhancing the use of technology in education in the post-pandemic era.

Keywords: Adaptation, Digital Literacy, Elementary Schools, COVID-19, Infrastructure, Online Learning, Remote Areas, Teacher Training.

Introduction

The COVID-19 pandemic, which began in 2020, forced the entire world, including Indonesia, to transition to remote learning in response to the closure of schools (Azhari & Fajri, 2022; Pradana & Syarifuddin, 2021; Sihombing et al., 2021). For many schools, especially those in remote areas and schools that had not previously implemented remote learning, this transition posed a significant challenge. These schools faced limitations in digital infrastructure, such as limited access to stable internet and a lack of adequate devices, making it difficult to conduct online learning effectively.

The low level of digital literacy among teachers and students is also a major barrier. Many teachers are not accustomed to using technology for teaching, while students often lack the necessary devices to participate in online learning (Alfiansyah et al., 2022; Hermanto & Srimulyani, 2021; Lukas & Yunus, 2021). This situation exacerbates educational inequality in Indonesia, where schools that are not prepared for distance learning are forced to adapt in limited and suboptimal ways, impacting the quality of education received by students.

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To address this challenge, it is essential for schools that are just beginning to adopt distance learning to receive support in terms of technology training for teachers and the provision of better infrastructure. Effective technology adaptation, such as the use of instant messaging applications for learning communication and the development of easily accessible materials, can help bridge this gap (Memon & Memon, 2025; Oguntimehin & Kolawole, 2024; Singer, 2025). However, to ensure the sustainability and quality of education in the future, collaboration between the government, society, and the private sector is needed to improve ICT infrastructure and digital capabilities at all levels of education.

Although remote learning has become the primary alternative during the COVID-19 pandemic, many schools, especially those that had never implemented it before, face significant challenges in its implementation (Clarin & Baluyos, 2022; Hurwitz et al., 2022; Mushtaha et al., 2022). These schools, whether located in remote areas or regions with limited digital infrastructure, were forced to switch to online learning in a less-than-optimal manner. The limitations of devices, unstable internet connections, and the lack of technological understanding among teachers and students have caused the learning process to be ineffective.

Many teachers lack sufficient digital skills to adapt their teaching methods for online instruction, which worsens their unpreparedness in using technology as a medium for learning. Students in these schools often do not have adequate devices or stable internet access, making it difficult for them to fully participate in online lessons (Catalano et al., 2021; Hermanto & Srimulyani, 2021; Yan et al., 2021). This results in a gap in the quality of education between schools that are equipped with technology and those that are not, exacerbating educational inequality in Indonesia, especially during the pandemic (Leonard & Saphira, 2021; Putri, 2025; Warliani & Fauziyyah, 2020). It is important to identify and address the barriers faced by schools that have just started implementing remote learning, so that they can optimize the use of technology in education. This study aims to explore the challenges faced by these schools and find solutions to help them adapt to educational technology in the face of the ongoing pandemic crisis.

The main objective of this study is to explore the challenges faced by schools that had never implemented remote learning (PJJ) before but were forced to do so during the COVID-19 pandemic. This research aims to identify various barriers in technology adaptation, including infrastructure issues, device limitations, and the digital literacy of both teachers and students. Additionally, this study also seeks to evaluate the impact of technology implementation on the quality of education, particularly in enhancing students' literacy and numeracy amidst the existing limitations.

This study focuses on efforts to find solutions for schools that have just begun adapting to technology, by providing recommendations related to teacher training, improving digital infrastructure, and methods to enhance the effectiveness of online learning. The research also aims to analyze the sustainability of using educational technology in the future, after the pandemic ends, so that technology can continue to be leveraged to support more inclusive and quality education in schools that were previously unprepared for remote learning.

This research holds significant importance in the context of education in Indonesia, particularly in addressing the widening digital gap caused by the COVID-19 pandemic. By exploring the challenges faced by schools that have just implemented remote learning, the study can provide a deeper understanding of the barriers that arise, including those related to infrastructure, digital skills, and student readiness. The findings of this research are expected to contribute to the formulation of educational policies that are more responsive to the needs of schools in regions that were not prepared to implement technology in education.

Method

This study uses a case study approach to explore the adaptation of technology in education at SDN 216 Sondariah, a school located in Bandung, West Java, which had never implemented remote learning before. This school falls into the category of those that were forced to switch to online learning due to the COVID-19 pandemic, despite having limited infrastructure and technological readiness. By

using the case study method, this research aims to deeply investigate how the school adapted to technology in order to continue education during the pandemic.

The location of this research is SDN 216 Sondariah, located at Jl. Rancanumpang, Bandung City, West Java. The school has 205 students from grades 1 to 6, with a total of 12 teachers and staff. As a school situated in an area with limited access to technology, it faces significant challenges in implementing online learning. Therefore, this research focuses on the school's experience in applying technology, both in online learning through applications such as WhatsApp, Zoom, and Google Meet, as well as other efforts to improve technological understanding among teachers and students.

Data for this research were collected through participatory observation, in-depth interviews with teachers, the school principal, and students, as well as documentation of learning activities conducted during the online learning period. The observation took place over several months, from August to December 2021, to understand how the school adapted technology in the learning process. Interviews were conducted with teachers directly involved in online learning to identify the challenges they faced in using technology, as well as their experiences in teaching using online methods. Interviews were also conducted with students to understand how they adapted to learning with technology and the challenges they encountered, particularly in terms of device limitations and internet connectivity.

In addition to observation and interviews, this research also collected data in the form of documents and activity reports related to the adaptation of technology at SDN 216 Sondariah. These documents include the online learning program plans, learning materials created by teachers using technology, and evaluation notes on learning outcomes. The collected data were then analyzed qualitatively to describe how technology was used in the learning process at the school, identify the barriers faced, and evaluate its impact on improving the quality of education, particularly in terms of students' literacy and numeracy.

The analysis method used is thematic analysis, where the data obtained from observation, interviews, and documentation are analyzed to identify key themes related to the challenges and solutions in technology adaptation (Christou, 2022; Wæraas, 2022). This research aims to provide a clear picture of how technology can be integrated into learning in elementary schools that previously had no experience with remote learning, as well as how this adaptation process can be optimized to improve learning effectiveness in the future.

Result and Discussion

Technology Adaptation in Teaching and Learning

During the COVID-19 pandemic, SDN 216 Sondariah, which had never implemented distance learning before, was forced to switch to technology to continue the learning process. The school utilized WhatsApp, Zoom, and Google Meet as the main platforms for online learning. WhatsApp was used to share learning materials and communicate with students, as shown in Figure 1, while Zoom and Google Meet were used for virtual classes. Despite facing challenges related to limited devices and internet connections, the use of these applications enabled communication between teachers and students to continue, although it was not entirely effective in improving student understanding (Almufarreh & Arshad, 2023; Badshah et al., 2023).

Figure 1. Excerpts from Online Learning Using WhatsApp

The implementation of technology faced various challenges. Many students did not have adequate devices, so they had to share devices with other family members or use mobile phones with small screens, which disrupted the learning process. In addition, the limited and unstable internet connectivity in the area also slowed down the smoothness of online learning. Nevertheless, the school made efforts to optimize the use of technology by dividing students into small groups for more effective online learning sessions via video calls and providing materials in more accessible formats, such as audio and text (Lapitan Jr et al., 2021; Li, 2022; Shamir-Inbal & Blau, 2021).

The adaptation of technology involved not only students but also teachers. Most teachers at SDN 216 Sondariah had not been trained in using technology for teaching prior to this. Therefore, basic training on the use of applications like Canva for creating interactive teaching materials and training on the use of Zoom and Google Meet were conducted to enhance the teachers' digital skills. While some teachers showed progress, there were still shortcomings in fully utilizing technology. This research shows that although technology can support learning, its success heavily depends on the readiness of infrastructure, teachers' digital capabilities, and students' access to adequate devices and internet connectivity (Aditya, 2021; Rawal, 2024; Timotheou et al., 2023).

Challenges Faced by Teachers and Students

During the implementation of remote learning at SDN 216 Sondariah, both teachers and students faced several major challenges in adopting technology. One of the main challenges faced by teachers was the lack of digital skills. Most teachers were not accustomed to using technology in the learning process, which hindered their effectiveness in delivering content online. Although some training sessions were provided, teachers' understanding of how to use applications like Zoom, Google Meet, and Canva remained limited. This resulted in the learning process often being suboptimal, as teachers struggled to create engaging materials and interact effectively with students (Chew & Cerbin, 2021).

Infrastructure issues became a major barrier in the implementation of remote learning. Many students did not have adequate devices, such as laptops or suitable smartphones, to participate in online learning. Most students only had phones with small screens, which made it difficult for them to fully engage in lessons. Poor internet connectivity further worsened the situation, as many students lived in areas with limited or unstable internet access. This led to many students struggling to consistently access learning materials and follow online lessons smoothly (Erlangga, 2022; Lemay et al., 2021; Means & Neisler, 2021).

The readiness of students and parents also plays a crucial role in the success of technology adaptation. Many parents struggled to support their children in online learning, especially those who lacked basic knowledge of technology. Students from families with lower educational backgrounds or those without additional devices at home faced greater difficulties in engaging in learning effectively. While some parents made significant efforts to assist, the lack of digital skills among parents became an additional barrier in supporting their children's learning. This further widened the educational gap between students with adequate access to technology and those without (Afzal et al., 2023; Graves et al., 2021; Irvani et al., 2020).

Impact on Literacy and Numeracy

The use of technology at SDN 216 Sondariah, despite facing numerous challenges, has had a significant impact on improving students' literacy and numeracy. In terms of literacy, the use of learning videos and online quizzes helped students better understand basic concepts, such as reading and writing. Materials presented in an audio-visual format assisted students who struggled with traditional text-based learning, as they could both see and hear the information being presented directly. Additionally, the presence of interactive online quizzes motivated students to engage more with the lessons and review the material, thus enhancing their understanding (Muir et al., 2022; Nuci et al., 2021; Rohman et al., 2025).

Despite progress, challenges in literacy are still evident, particularly among students who struggle to fully understand sentences or read fluently. Some students still have difficulty reading fluently, even after various reading exercises were conducted through online media. A large number of lower-grade students continue to face difficulties with letter recognition and word formation. This

indicates that while technology can be an effective tool in enhancing literacy, there is a greater need for a more personalized and sustained approach to help students who require additional attention (Felesia & Irvani, 2025; Kalyani, 2024).

In the field of numeracy, the application of technology has also had a positive impact. Activities such as multiplication dice games and online math quizzes helped students better understand multiplication concepts and basic math in a more interactive and enjoyable way (Saadah et al., 2025; Yang et al., 2021). However, the learning outcomes indicate that many students still have not reached an adequate level of understanding, particularly when it comes to applying mathematical concepts to everyday life. The improvement of students' literacy and numeracy can be maximized if technology is used alongside more personalized conventional teaching methods, supported by adequate infrastructure.

Teacher Training and Capacity Building

The technology training provided to teachers at SDN 216 Sondariah focused on the use of graphic design applications such as Canva to create more creative and engaging learning materials. Before the pandemic, most teachers at the school were not accustomed to using technology to develop teaching materials. Therefore, the Canva training was conducted to help teachers create infographics, posters, and other interactive materials that could make it easier for students to understand learning concepts. The training took place in November 2021 and was attended by several teachers who were directly involved in the remote learning process.

Although the number of training participants was limited, mainly due to time constraints and limited facilities, the training had a significant impact on the teachers' creativity in preparing teaching materials. Teachers who previously relied solely on traditional methods began to shift towards more visual and interactive learning materials, better suited to the needs of students in the digital era. The use of Canva allowed teachers to present learning materials in more engaging formats, such as infographics and short videos, which helped students better understand and retain the material being taught (Fitria, 2024; Susanti et al., 2024).

Although the training had a positive impact on improving the creativity of teaching materials, there are still challenges in fully utilizing technology. Some teachers still feel limited in their technical skills and have not fully mastered the various features of the available applications. Therefore, advanced training and more intensive mentoring are essential to enable teachers to optimize the use of technology in teaching. With more structured and ongoing training, it is hoped that the quality of teaching can continue to improve, and teachers can become more effective in utilizing technology to support future learning (Almufarreh & Arshad, 2023; Meisuri et al., 2023; Onu et al., 2024).

Sustainability of Technology Use

The sustainability of technology use in schools like SDN 216 Sondariah after the pandemic is a key factor in ensuring that the digital transformation in education is not just an emergency response but also a long-term effort to improve the quality of learning. One of the main aspects that needs attention is ongoing training for teachers. While training on using applications such as Canva and Zoom has been conducted, many teachers still require continuous support and skill enhancement in technology. Ongoing training will help them master more applications and digital learning tools, enabling them to make learning more interactive and engaging, as well as address the challenges associated with using more complex technologies (Fitria, 2024).

Improving infrastructure in remote schools is also crucial in ensuring the sustainability of technology use. Without adequate devices and stable internet connections, the implementation of technology in education will not be optimal. Therefore, it is important for the government and relevant institutions to provide support in terms of supplying devices, improving internet networks, and enhancing ICT facilities in schools that are still lacking. Without these improvements, schools in remote areas will continue to face barriers that limit their ability to fully utilize technology in learning (Liu et al., 2022).

The sustainability of technology use also depends on the awareness and commitment of all parties, including schools, the government, and society. For example, it is important to involve parents

in supporting the use of technology at home and ensure that students have adequate access to devices and internet connectivity. If these aspects can be addressed, technology will not only be a temporary solution during the pandemic but will also become an integral part of future education. Thus, technology can help create a more inclusive, efficient, and adaptive education system in line with the times (Gevorgyan, 2024; Karagianni & Drigas, 2023; Oyedokun, 2025).

Conclusion

In conclusion, the adoption of technology in elementary schools during the COVID-19 pandemic, especially in schools that had never implemented online learning (PJJ) before, proved to be a challenging yet transformative experience. SDN 216 Sondariah's transition to online learning revealed numerous obstacles, such as limited access to devices, unstable internet connections, and a lack of digital literacy among both teachers and students. Despite these challenges, the school made significant strides in utilizing technology like WhatsApp, Zoom, and Google Meet to maintain communication and facilitate learning. These efforts, though not without their shortcomings, highlighted the potential of technology to bridge educational gaps, particularly in areas where traditional teaching methods were no longer feasible.

The implications of this study are clear: to ensure the sustainability and effectiveness of digital learning, continued support in the form of teacher training and infrastructure development is essential. Teachers at SDN 216 Sondariah benefited from basic digital literacy training, yet there remains a need for ongoing professional development to help them fully harness the potential of digital tools. Additionally, the school's infrastructure, including access to reliable internet and adequate devices, must be strengthened to support long-term technology use. The collaboration between the government, educational institutions, and communities is critical in addressing these issues and ensuring that all schools, especially those in remote areas, can continue to provide quality education through technology.

Moving forward, it is recommended that the government invest more in digital infrastructure and support teachers with regular training to enhance their technological capabilities. Schools must also prioritize inclusive access to technology for students, ensuring that no child is left behind due to a lack of resources. By addressing these key areas, the shift to digital education can be fully optimized, providing students with an equitable learning experience regardless of their geographical location or socio-economic status. The lessons learned during the pandemic can serve as a foundation for a more resilient, flexible, and inclusive education system in the future.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article. Neither financial, personal, nor professional relationships have influenced the content or conclusions of this research. All funding sources, affiliations, and potential biases have been disclosed to ensure transparency and uphold the integrity of the research.

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