East Asian Journal of Multidisciplinary Research (EAJMR)
Vol. 3, No. 8, 2024 : 3763 - 3776

Opportunities and Challenges in Implementing Information Technology Innovations in the Indonesian Education Sector

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A R T I C L E I N F O

Keywords: Technology Innovation, Education Accessibility, Research and Development

Received : 14, July
Revised : 27, July
Accepted: 29, August

A B S T R A C T

This research explores the opportunities and challenges in implementing information technology (IT) innovations in Indonesia's education sector. The study examines key variables such as infrastructure, internet access, and teacher training, using qualitative methodologies including case studies and literature reviews. Data were collected from various sources over the past decade. Findings highlight that while IT can enhance education quality and access, particularly through e-learning and digital tools, significant barriers remain due to Indonesia's geographical diversity and unequal infrastructure. The research suggests strategies for overcoming these challenges, such as accelerated infrastructure development, increased research funding, and comprehensive teacher training programs. These insights aim to inform policy and practice, enhancing IT integration in Indonesian education.

DOI prefix: https://doi.org/10.55927/eajmr.v3i8.10686
ISSN-E: 2828 - 1519
https://journal.formosapublisher.org/index.php/eajmr

INTRODUCTION

Information technology has become a key element in the transformation of various sectors, including education. The use of information technology in education covers various aspects such as e-learning, school information management, and digital tools for teaching and learning. These technologies not only improve the efficiency of education administration but also open up access to various educational resources that were previously unreachable. For example, with the internet, students in remote areas can access the same subject matter as students in big cities. In addition, information technology enables more interactive and personalized learning methods, which can improve student motivation and learning outcomes. The importance of information technology in education can also be seen from its ability to support distance learning, which has become especially relevant during emergency situations such as the COVID-19 pandemic (Sani et al., 2024).

In Indonesia, the relevance of information technology in education is particularly high given the country's geographical and demographic challenges. Indonesia is made up of thousands of islands with varying levels of accessibility, which makes the dissemination of quality education a major challenge (Sudipa et al., 2023). Information technology can be a solution to address the education gap in different regions by providing online learning platforms and digital tools that can be accessed from anywhere. The Indonesian government has recognized the importance of information technology in education and has launched various initiatives to encourage the use of technology in schools. However, the implementation of information technology in Indonesia's education sector still faces various challenges such as limited infrastructure, unequal internet access, and lack of training for teachers in using technology (Subroto et al., 2023). Therefore, this study aims to explore the opportunities and challenges in the implementation of information technology innovations in Indonesia's education sector as well as the efforts needed to overcome these barriers and maximize the benefits of information technology in education.

This research aims to identify and analyze various key issues related to the implementation of information technology innovations in the Indonesian education sector. Some of the key issues to be addressed in this research include: how the opportunities of increasingly accessible information technology can be utilized to improve the quality of education in Indonesia; what are the main challenges faced in the implementation of information technology in the Indonesian education sector, especially related to the size of the region and the inequality of electricity and internet networks; what efforts have been and can be made to accelerate the development of electricity and internet network infrastructure in unreached areas; to what extent research and development activities in the Indonesian education sector are supported by adequate funding, and what are the strategies to achieve the research funding target of 5% of GDP; and what are the policies and strategies that can be adopted by the government and educational institutions to overcome the challenges of information technology implementation and effectively utilize the

existing opportunities. This research will provide in-depth insights into the actual conditions and strategies that can be implemented to overcome the challenges and maximize the benefits of information technology in education in Indonesia.

Research Objectives

This research aims to explore the opportunities, challenges and efforts required in the implementation of information technology in Indonesia's education sector. Specifically, this research aims to :

1. Identify and analyze how accessible information technology opportunities can be used to improve the quality of education in Indonesia.
2. Evaluate the main challenges faced in implementing information technology in the education sector, especially in relation to the size of the region and the inequality of electricity and internet networks.
3. Review the efforts that have been and can be made to accelerate the development of electricity and internet network infrastructure in unreached areas.
4. Assess the extent to which research and development activities in Indonesia's education sector are supported by adequate funding and develop strategies to achieve the research funding target of 5% of GDP.
5. Formulate policies and strategies that can be adopted by the government and educational institutions to overcome the challenges of information technology implementation and effectively utilize the existing opportunities.

This research is expected to provide in-depth insights and practical recommendations to maximize the benefits of information technology in education in Indonesia

LITERATURE REVIEW

Information Technology Opportunities in Education

Information technology (IT) has proven to have great potential in improving education quality and accessibility in many parts of the world. Various literatures show that IT can be used to support interactive and personalized learning, which in turn can improve student learning outcomes. For example, e-learning and online learning platforms allow students to access educational materials at any time and from anywhere, which is particularly useful for reaching students in remote areas or those who have physical limitations to attend traditional classes (Anderson, 2011 ; Bates, 2019).

In addition, information technology can also facilitate the management of school administration more efficiently, such as in the management of student data, attendance, and academic evaluation. With a school information management system (SMIS) in place, administrative processes become more organized and transparent, which in turn can improve the effectiveness of school operations (Anastasopoulou et al., 2024). Digital literacy acquired through the use of IT in education also prepares students to face challenges in an increasingly technology-dominated world of work. IT-based programs, such as coding and robotics, can provide relevant skills and support the

development of critical thinking and problem-solving abilities (Beetham & Sharpe, 2013).

Information technology can assist in providing richer and more diverse educational resources. For example, educational apps and software offer a variety of multimedia content, such as videos, animations and simulations, which can enhance students' understanding of complex material (Mayer, 2009). In addition, technology also enables global collaboration between students and teachers from different countries, broadening their horizons and learning experiences (Dillenbourg, 2013). With all these advantages, IT offers a great opportunity to improve the quality of education and make it more inclusive and accessible to all students in Indonesia.

Implementation Challenges in Indonesia

The implementation of information technology in education in Indonesia faces a number of significant challenges, mostly stemming from geographical factors and uneven infrastructure. As the largest archipelago in the world, Indonesia has unique geographical challenges. Long distances between islands and diverse topographical conditions make the distribution of information technology infrastructure very challenging (Dina, 2017).

Inequality in access to electricity and internet is one of the main challenges. According to a report from the Indonesian Ministry of Communication and Information Technology (2022), there are still many areas in Indonesia that are not covered by adequate electricity and internet networks. This leads to a significant digital divide between urban and rural areas. This impacts the gap in access to technology-based educational resources, which should be utilized by all students in Indonesia (Kominfo, 2022).

Another obstacle is the lack of supporting infrastructure such as hardware and software in schools. Many schools, especially in remote areas, still lack computers, network devices and other technology equipment. In addition, device maintenance and updates are often a problem due to limited funds and resources (Akbar & Noviani, 2019).

In addition, there are also challenges in terms of human resource readiness. Many teachers and educators do not have sufficient skills and knowledge to utilize information technology in the teaching and learning process. Lack of training and professional development programs is one of the main causes (Umardulis, 2019).

Other challenges include policies and regulations that do not fully support the integration of technology in education. Although the government has undertaken various initiatives, implementation in the field often does not go as planned due to a lack of coordination between the various parties involved (Fitriansyah, 2024).

Thus, while information technology has great potential to improve the quality of education in Indonesia, the challenges of geography, infrastructure inequality and other barriers must be overcome through the concerted efforts of the government, educational institutions and communities.

Implementation Efforts and Strategies

Various countries have successfully implemented information technology in education with strategies that can be valuable lessons for Indonesia. These strategies include infrastructure development, teacher training, and supportive policies and regulations.

In South Korea, the government is aggressively building technology infrastructure by ensuring every school has high-speed internet access. Their "Smart Education" program includes the distribution of tablets to students and the development of comprehensive digital educational content (Chun, 2017). South Korea's success demonstrates the importance of government commitment in investing in technology infrastructure to support education.

Finland is also known as one of the countries with the best education system that integrates information technology. They focus on teacher training and professional development to ensure that technology is used effectively in the teaching and learning process. Continuous training programs and technical support to teachers are key to their success (Cahyani, 2023 ; Global, 2024).

In Singapore, the government's strategy for integrating information technology into education involves a holistic approach that includes technology-based curriculum, infrastructure development, and improving digital literacy among students and teachers. Their "Masterplan for ICT in Education" program emphasizes the use of technology to promote more interactive and collaborative learning (Lim, 2007).

To adapt these strategies in Indonesia, there are several steps that can be taken. First, accelerate the development of electricity and internet network infrastructure in unreached areas. This requires significant investment from the government as well as cooperation with the private sector (Kemdikbud, 2020).

Second, strengthen research and development (R&D) activities in education technology with adequate funding support, reaching at least 5% of GDP. This will include the development of digital education content that is relevant and appropriate to the local context (Nasir, 2014).

Third, implement a continuous training program for teachers to ensure they have the necessary skills to integrate technology in the learning process. In addition, technical support and resources should be provided to assist teachers in overcoming technical challenges (Berry, 2024).

Fourth, formulate policies and regulations that support the use of information technology in education. This includes incentivizing schools that successfully adopt technology effectively and creating national standards for technology integration in the curriculum (Rabani et al., 2023).

By adopting these strategies, Indonesia can overcome the challenges and maximize the opportunities offered by information technology to improve the quality of education.

RESEARCH METHODOLOGY

This research uses a qualitative approach with a case study method and literature review. The qualitative approach was chosen because it allows researchers to gain an in-depth understanding of the context and complexity of

the problem being studied. Case studies provide detailed descriptions of specific phenomena in real-life situations, while literature reviews allow researchers to explore findings from relevant previous research (Subakti et al., 2023).

RESULTS AND DISCUSSION

Information Technology Implementation Opportunities

Technology is becoming more accessible to the public

The results show that access to information technology is increasingly widespread in various layers of Indonesian society. Increased internet penetration and the use of mobile devices such as smartphones and tablets have opened up great opportunities for technology integration in education. Data from the Indonesian Internet Service Providers Association (APJII) that by 2024 shows that around 79.5% of the Indonesian population has access to the internet, which means that more than 221.6 million people can connect to the digital world (Kominfo, 2024). Data on the development of internet penetration in Indonesia from 2015-2024 can be seen from the following table :

Year	Number of internet users (million)	Percentage of Population Accessing the Internet (%)	Source
2015	93,4	36	APJII, 2015
2016	102,8	39	APJII, 2016
2017	132,7	50	APJII, 2017
2018	171,2	64,8	APJII, 2018
2019	196,7	73,7	APJII, 2019
2020	175,4	73,7	APJII, 2020
2021	210,0	77,0	APJII, 2021
2022	212,6	77,2	APJII, 2022
2023	215,6	78,2	APJII, 2023
2024	221,6	79,5	APJII, 2024

Source : Indonesia Internet User Penetration Data 2015-2024 (APJII)

The data provides an opportunity for schools, both urban and rural, to utilize information technology in the learning process. These technologies not only help in the distribution of educational materials but also enable more interactive and personalized learning. For example, e-learning platforms and educational apps have been widely used by teachers and students to complement traditional teaching and learning activities

Adaptation and Mitigation Required for Effective Implementation

Despite widespread access to technology, effective implementation still requires adaptation and mitigation of various challenges. One important adaptation is the provision of training and professional development for teachers. Research found that many teachers lack confidence in using information technology effectively in their teaching. Therefore, ongoing training programs focused on improving teachers' digital skills are needed. In addition, adapting

the curriculum to integrate information technology holistically is also a crucial step. A customized curriculum can ensure that the use of technology is not just as an additional tool but as an integral part of the learning process.

Mitigating infrastructure challenges is also very important. In some areas, especially in rural and remote areas, inequality in electricity and internet access is still a major obstacle. To address this, the government needs to accelerate the development of telecommunications infrastructure and electricity networks in unreached areas. A community-based approach, where schools work together with local communities and the private sector, can also help in overcoming resource limitations.

With greater opportunities and appropriate adaptation and mitigation measures, the implementation of information technology in education in Indonesia can have a significant impact on improving the quality and accessibility of education. It will also support the government's efforts in creating a more inclusive and technology-driven education system, in line with Indonesia's vision to become an advanced digital economy.

Challenges and Implementation

Indonesia's Large Area and Geographical Challenges

Indonesia is the largest archipelago in the world, with more than 17,000 islands spread along the equator. This geographical challenge makes the distribution of information technology infrastructure very complex and expensive. Many remote areas are difficult to reach, either due to geographical remoteness or challenging topographical conditions, such as mountains, dense forests and vast oceans (World Bank, 2021). This geographical disparity in access results in some areas having excellent technology infrastructure, while other areas have almost no access at all. This has a direct impact on the ability of schools in remote areas to access and utilize information technology in their learning process.

Inequality in Electricity and Internet Networks in Different Regions

One of the biggest challenges in implementing information technology in the education sector in Indonesia is the inequality in electricity and internet networks. According to President Joko Widodo, quoted from a report from the Presidential Secretariat Bureau, there are about 433 villages out of 75 thousand villages in Indonesia that have not been electrified. The 443 villages are located in eastern Indonesia, namely in Papua 325 villages, West Papua 102 villages, NTT 5 villages and Maluku 1 village (Brtita Artikel & Terpopuler, 2024). Meanwhile, 12,000 villages in Indonesia are still not covered by adequate internet access (Kominfo, 2022). Urban areas generally have better infrastructure compared to rural and remote areas. For example, internet penetration in urban areas reaches more than 80%, while in rural areas it is still much lower. This disparity results in students and teachers in remote areas being unable to utilize digital education resources, which is especially important in emergency situations such as the COVID-19 pandemic.

Addressing these challenges requires a coordinated effort between the government, private sector, and communities. Sustainable infrastructure development and investment in electricity and internet networks in unreached areas are critical first steps. In addition, training programs and digital skills development for teachers and students should be prioritized to ensure that information technology can be used effectively in the learning process across Indonesia (UNESCO, 2018).

Efforts and Solutions

Accelerating Infrastructure Development in Unreached Areas

One important step to address the inequality of access to information technology in Indonesia is to accelerate infrastructure development in unreached areas. The government has launched several initiatives such as the Integrated Broadband Village Program which aims to provide internet access in remote villages (Dhahir, 2018). The program aims to ensure that all villages in Indonesia have internet access, so that all students and teachers can utilize information technology for learning. According to the Ministry of Communication and Informatics (Kominfo), by 2022, many villages will start to get internet access thanks to this program (Kominfo, 2022).

In addition, collaboration between the government and the private sector is also needed to build a wider and more reliable network infrastructure. The government can incentivize telecommunications companies to expand their coverage to underserved areas. For example, subsidies or tax incentives could be given to companies willing to build infrastructure in remote areas. Cooperation with private companies will not only accelerate infrastructure development, but also ensure that the networks built are of high quality and reliability (World Bank, 2021).

With better infrastructure development, schools in remote areas will be able to access the same digital education resources as urban schools. This will help reduce the education gap between urban and rural areas. For example, with better internet access, students in remote areas can take online classes, access digital learning materials and participate in distance education programs. In addition, teachers in remote areas can also join online training programs to improve their skills in using information technology in the teaching process (UNESCO, 2018). These infrastructure improvements are expected to not only improve the quality of education in remote areas but also open up new opportunities for economic and social development in these areas.

Strengthening Research and Development Activities with Adequate Funding Support

To ensure that information technology can be effectively applied in education, there is a need to strengthen research and development (R&D) activities. R&D plays a crucial role in creating technological innovations that are relevant and effective for the local education context. For example, research can help develop educational software tailored to the national curriculum or more effective teaching methods utilizing technology. In addition, research can also identify specific challenges faced by Indonesian schools and formulate appropriate solutions. According to a UNESCO report, countries that

successfully integrate technology in education are those with significant and continuous R&D investments.

In Indonesia, increasing the allocation of funds for R&D can be done through supportive fiscal policies. The government could provide a special budget for R&D in the education sector in the State Budget (APBN). In addition, tax incentives for companies investing in education R&D could also be one strategy to increase investment in this area. With these incentives, technology companies will be more encouraged to conduct research and development of products or services that can support education in Indonesia. This is in line with the approach applied in some developed countries, where tax incentives are used to encourage private investment in R&D.

In addition to support from the government, collaboration between educational institutions and industry is also crucial in strengthening R&D. Universities and schools can work together with technology companies to develop innovative educational solutions. For example, partnership programs between universities and technology companies can generate research that focuses on real needs in the field and accelerate the application of research results in daily educational practices. This approach not only strengthens the R&D ecosystem but also ensures that the technologies developed truly fit the needs of education in Indonesia (OECD, 2019). With this strategy, Indonesia can strengthen its R&D capacity and ensure that information technology is used effectively to improve the quality of education.

Strategies to Achieve the Research Fund Target of 5% of GDP

To achieve the research funding target of 5% of Gross Domestic Product (GDP), several strategies can be implemented with a comprehensive and sustainable approach. First, the government should increase the education budget and ensure that a portion of the budget is allocated specifically for research and development. According to (OECD, 2019), countries that manage to achieve high levels of R&D investment usually have a strong government commitment in allocating budgets for education and research. In the Indonesian context, the government can increase the percentage of the state budget allocation for education and arrange for a significant portion of the budget to be dedicated to R&D projects. This will ensure that sufficient funds are available to support various research initiatives and technological innovations in education.

Second, encouraging partnerships between the public and private sectors for joint investment in R&D projects is another key strategy. A matching fund program, where the government matches the funds invested by companies in education R&D, can be an effective incentive. This initiative not only increases total investment in research but also encourages private companies to actively participate in educational technology development. Public-private partnerships can bring significant benefits, including access to additional resources, increased research capacity, and transfer of knowledge and technology from the private sector to educational institutions. Thus, close collaboration between government, universities and industry will accelerate innovation and technology applications in education.

Third, improving transparency and accountability in the use of R&D funds is essential to ensure that the funds are used effectively and efficiently. The government should implement strict monitoring and reporting mechanisms to oversee the allocation and use of R&D funds. Transparency in fund management will encourage trust from all stakeholders and ensure that each investment yields the desired results. According to the report (UNESCO, 2018) transparency and accountability in the management of education funds are key factors in the success of government-funded education programs. By publishing regular reports on the use of funds and the results achieved, the government can demonstrate its commitment to using public funds in a responsible and results-focused manner.

CONCLUSIONS AND RECOMMENDATIONS

This research found that the implementation of information technology in education in Indonesia faces significant opportunities and challenges. The main opportunities identified include easier access to information technology for the general public. Increased internet penetration and the use of mobile devices such as smartphones and tablets have opened up great opportunities for technology integration in education. This enables wider distribution of educational materials and more interactive and personalized learning. However, to effectively capitalize on these opportunities, appropriate adaptation and mitigation are required to deal with the challenges.

The main challenges faced include Indonesia's vast territory and infrastructure inequality, especially in terms of electricity and internet networks in various regions. This creates an education gap between urban and rural areas. Accelerating infrastructure development is crucial to ensure all regions have equal access to information technology. In addition, strengthening research and development (R&D) activities with adequate funding support is a crucial step to overcome this challenge. Strategies to achieve the research funding target of 5% of GDP include increasing the education budget, partnerships between the public and private sectors, and improving transparency and accountability in the use of funds. By implementing these strategies, Indonesia can overcome the challenges and maximize the benefits of information technology in education

A. For policymakers

1. Increase education budget : allocate a larger budget for education and ensure a significant portion of the budget is dedicated to research and development. This is important for creating technological innovations that are appropriate to the local context.
2. Accelerate infrastructure development : continue and expand programs such as the Integrated Broadband Village Program to ensure all areas, including remote ones, get adequate internet access. Incentivize telecommunications companies to build infrastructure in underserved areas.

B. For educational institution

1. Collaboration with industry : establish partnerships with technology companies to develop innovative education solutions. Partnership programs

can include joint research, digital education content development and training for teachers in the use of technology.
2. Training and professional development : invest in ongoing training programs for teachers to improve their digital skills. This training should include the use of technology devices and applications in the learning process.

C. For other related parties

1. Transparency and accountability : implement strict monitoring and reporting mechanisms to oversee the use of R&D funds. Publish periodic reports on the use of funds and results achieved to encourage trust and ensure that funds are used effectively.
2. Public-private partnerships : encourage private companies to invest in education R&D projects through matching fund programs and tax incentives. This will increase total investment in research and ensure that technological innovation continues to flourish.

With the implementation of these recommendations, it is hoped that Indonesia can overcome the challenges in implementing information technology in education and capitalize on the opportunities that exist to improve the overall quality of education

FURTHER STUDY

Further research also needs to pay attention to aspects of financing and partnership models between the government and the private sector in funding research and development (R&D). Focusing on how this collaboration can improve the efficiency and effectiveness of education funding management and its impact on achieving the R&D funding target of 5% of GDP will be invaluable. This research can produce more appropriate policy recommendations to strengthen technological innovation in the field of education.

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