THE IMPACT OF USING ICT ON TEACHERS AND STUDENTS AT MINISTRY OF EDUCATION IN INDONESIA

BY

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(THESIS)

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Hereby declare that my thesis titled:

"The Impact of Using ICT on Teachers and Students Performance at Ministry of Education in Indonesia"

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BIOGRAPHY

Karim Azizi was born on December 19, 1997, in Bamyan, Afghanistan. He is the seventh child in a family of ten, cherished by his parents Sultan Azizi and Shagul Azizi. His upbringing was marked by values of perseverance, knowledge, and commitment to community service.

Karim embarked on his educational journey at Siyadara Sofllah Elementary School, graduating in December 2014. He continued his academic path at Neswan Siyadara Sofllah High School in Yakawlang District, Bamyan, Afghanistan, where he earned his SVQ Level 2: General certification with a GPA of 4.0.

Driven by his passion for technology, Karim pursued higher education at Kabul Polytechnic University, studying in the Faculty of Computer Science, Department of Computer Engineering. During his time at the university, he was an active member of the Active Youth Students Union and graduated with a Bachelor of Computer Science degree in December 2019, achieving a GPA of 3.30.

Karim's professional career includes significant roles in academia and the technology industry. He worked as a Software Developer at Car Town Transportation Company in Brampton, Canada, where he contributed to developing and optimizing software systems. Prior to this, he was an IT Expert at the National Statistics and Information Authority (NSIA) in Kabul, Afghanistan, where he managed network infrastructure and participated in capacity-building programs.

Karim has also volunteered as a Computer Science teacher at Kabul Polytechnic University, emphasizing practical programming skills. In 2024, he pursued a Master's in Educational Technology at the Faculty of Teacher Training and Education, University of Lampung, maintaining a GPA of 3.6 and focusing on leveraging technology to improve educational methodologies.

Karim Azizi's journey exemplifies dedication and an unwavering pursuit of knowledge, merging technology with education for community advancement.

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Karim Azizi

ABSTRACT

THE IMPACT OF USING ICT ON TEACHERS AND STUDENTS PERFORMANCE AT MINISTRY OF EDUCATION IN INDONESIA

By Karim Azizi

This study explores the factors influencing student performance through e-learning, using the Unified Theory of Acceptance and Use of Technology (UTAUT) model. Indonesia's unique geographical challenges and limitations in ICT infrastructure, particularly outside Java Island, contribute to slow educational development compared to advanced countries like Hong Kong and Singapore.

The research includes a literature review, expert interviews, and a survey of 200 tertiary students in Lampung, analyzed with SmartPLS 2. Key findings reveal that social influence, facilitating conditions, and effort expectancy significantly impact student behavior and performance, while performance expectancy does not. Additional variables, such as lecturer characteristics, external motivation, and organizational structure, show a direct effect on performance.

The study highlights the importance of lecturer characteristics, motivation, environment, and organizational support in enhancing student outcomes. Recommendations for policymakers and educators are provided to implement ICT-based strategies effectively, particularly in similar developing contexts.

Keywords: ICT in Education, UTAUT, Student Performance, E-learning, Educational Technology

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I. INTRODUCTION

Information and Communication Technology (ICT) has emerged as one of the most transformative forces in 21st-century education. Its potential to reshape traditional educational systems has been widely recognized, particularly in terms of enhancing teaching methodologies, modernizing learning environments, and driving educational reform. The use of ICT worldwide is often viewed as a tool to revolutionize education systems that may be outdated, providing opportunities for innovation and improvements in how teaching and learning are conducted. In developed countries, ICT has become an essential component of educational infrastructure, with governments making significant investments in educational technologies. Many of these nations are leading efforts to equip every student with digital tools, such as one laptop per student programs in primary and secondary schools. These initiatives reflect a widespread belief that ICT can be a critical driver of improved educational outcomes and global competitiveness.

However, the situation in developing countries presents a contrasting picture. Many of these nations, including Indonesia, are still grappling with the complexities of ICT implementation in education. Despite their recognition of the importance of ICT, these countries face numerous challenges, such as limited infrastructure, budget constraints, and a lack of comprehensive teacher training programs. Governments in these countries have begun to introduce national programs aimed at incorporating ICT into their educational systems, with efforts to provide schools with computers, projectors, internet access, and other technological tools. However, these programs have often placed a heavy burden on national education budgets, and in many cases, the outcomes have been limited. One reason for the limited success of these programs is the lack of a research-based approach, with initiatives often formulated outside the realm of education and without sufficient consideration of the needs and capacities of schools and teachers.

ICT encompasses a broad range of electronic devices, including computers, laptops, tablets, smartphones, and related technologies such as broadband internet, cloud computing, and interactive web platforms. For ICT to be effective in education, it requires an alignment of various elements, including infrastructure, supportive environments, and hu-

man resources. No matter how sophisticated the technology or how well-equipped the schools are, the success of ICT integration ultimately depends on the skills, knowledge, and attitudes of the people involved—namely, administrators, teachers, and students. Without adequate human resource development, ICT will not be fully utilized in the curriculum. This underscores the importance of ensuring that educational staff and students are adequately trained and prepared to make the most of the technological resources available to them.

Research has shown that teachers' attitudes towards ICT play a critical role in the success of technology integration in schools. Early studies highlighted that teachers' acceptance of ICT is closely tied to their attitudes and willingness to adopt new technologies. This highlights the need for teacher-centric studies when implementing ICT in educational settings. Understanding teachers' perspectives on ICT can have significant implications for how technology is used in the classroom and how effectively it enhances the learning process. Consequently, teacher training and professional development focused on ICT adoption are vital components of successful integration efforts.

Indonesia, a developing country in Southeast Asia, is actively working to enhance its educational system through the integration of ICT. The Ministry of Education and Culture (MOEC) has taken substantial steps towards modernizing the country's education system, with a particular emphasis on equipping schools with necessary ICT tools. The national plan includes providing schools with computer labs, projectors, laptops, and internet connections to better prepare students for the demands of a digital world. While significant progress has been made in urban areas, the situation in rural schools presents additional challenges. Schools in remote regions often lack the infrastructure and resources that are more readily available in cities. As a result, studies on the integration of ICT in Indonesian rural schools remain limited, and more research is needed to understand the unique challenges these schools face in leveraging technology for educational improvement. The disparities between urban and rural areas in Indonesia further complicate efforts to achieve nationwide ICT integration. Despite these challenges, the MOEC remains committed to promoting ICT as a critical component of 21st-century education in Indonesia, recognizing its potential to narrow educational gaps and enhance learning outcomes across the country (Mahdum et al., 2019).

To truly harness the benefits of ICT, Indonesia must address several key factors. These include providing adequate training and professional development for teachers, particularly in rural and remote regions, where access to quality training is often limited. Teachers are the key drivers of ICT implementation, and their ability to effectively use these tools in the classroom is crucial to student success. Additionally, the government must invest in the necessary infrastructure, such as reliable internet connections and well-maintained ICT

facilities, to ensure that all students have equal access to these resources, regardless of their location.

Another significant challenge is the need for curriculum reform that integrates ICT into all subjects, rather than treating it as a standalone course. This would help to ensure that technology is used as a tool to enhance learning across the curriculum, making education more interactive and engaging for students. Curriculum designers and educational policymakers must work closely with teachers to develop ICT-based teaching strategies that are aligned with students' learning needs and the realities of classroom environments in both urban and rural schools.

Moreover, the success of ICT integration in Indonesian education also depends on creating a supportive policy environment. Policymakers must recognize the unique challenges faced by different regions and schools across the country and develop strategies that are responsive to these local needs. A one-size-fits-all approach to ICT implementation is unlikely to succeed in a country as diverse as Indonesia. Instead, a more flexible, region-specific approach that allows for localized solutions will be more effective in addressing the diverse challenges of ICT integration in Indonesian schools.

The development of partnerships between the public and private sectors also plays a crucial role in advancing ICT in education. Collaborations with technology companies, NGOs, and international organizations can provide the expertise, resources, and support needed to scale up ICT initiatives. These partnerships can also help bridge the gap between urban and rural schools, ensuring that students in remote areas are not left behind in the digital revolution.

Finally, ongoing monitoring and evaluation of ICT initiatives are essential to measure their impact and effectiveness. By regularly assessing the progress of ICT integration in schools, the government and educational institutions can identify areas for improvement and make necessary adjustments to ensure that all students benefit from the digital learning environment. These assessments should include feedback from teachers, students, and other stakeholders to ensure that ICT implementation is responsive to the needs of the education system.

Table 1.1: Summary of the Introduction

Point	Description
1. Importance of ICT in Education	ICT has revolutionized 21st-century education by enhancing teaching methods, promoting educational betterment, and addressing outdated educational systems.
2. ICT in Developed Countries	Governments in developed countries heavily invest in educational ICT, with some providing laptops for every student in primary and secondary schools.
3. ICT in Developing Countries	Many developing countries struggle with ICT implementation, although some have initiated national programs to introduce computers, laptops, and internet access into education.
4. ICT Challenges in Education	Even with ICT tools available, human resources (teachers, students, administration staff) often lack the necessary skills and knowledge to fully integrate these technologies into the curriculum.
5. Teachers' Attitudes Towards ICT	Teachers' attitudes play a crucial role in the success of ICT integration. Research shows that teacher attitudes are key to both initial and future acceptance of ICT in the classroom.
6. ICT in Indonesia	Indonesia, through its Ministry of Education and Culture, is actively promoting ICT integration in schools, providing tools like computers, projectors, and internet access.
7. ICT in Rural Areas	Studies on ICT in Indonesian schools have largely focused on urban areas, leaving a gap in research on ICT implementation in rural regions.

1.1 Background

In 2013, the Indonesian government took a significant step toward modernizing its educational system by introducing an ICT-based curriculum known as the 2013 Curriculum. The primary objective of this curriculum was to integrate ICT into all subjects as both learning resources and instructional media. The initiative was driven by the growing recognition

that ICT has the potential to enhance teaching and learning processes, fostering creativity, critical thinking, and digital literacy among students. This nationwide mandate was seen as a pivotal moment in the country's education sector, setting the stage for a broader shift towards technology-enhanced education.

Despite these advancements, the implementation of ICT in Indonesian education has faced several challenges. A large body of research has emerged that examines teacher perceptions, attitudes, and motivations towards ICT usage in the classroom. However, much of this research has been concentrated in urban areas, where access to ICT infrastructure is more readily available, and teachers are generally more familiar with technology. This urban-centric focus has left a critical gap in understanding how ICT is perceived and utilized in rural areas, where the educational context differs significantly from that of urban regions.

Teachers in rural districts face a unique set of challenges when it comes to the integration of ICT in their teaching practices. Limited access to modern technology, insufficient ICT training, and a lack of support from educational authorities are common issues in these areas. Additionally, many rural schools lack the basic infrastructure needed to support ICT, such as reliable electricity and internet connectivity. As a result, teachers in these regions may feel less confident in their ability to use ICT effectively, and students are often deprived of the potential benefits that technology can bring to their learning experiences.

While there has been an increasing number of studies investigating teacher perceptions and motivation to use ICT in teaching, little research has focused on teachers in rural districts in Indonesia. Most of the existing literature tends to focus on urban areas, which, while informative, does not fully capture the diversity of educational environments across the country. This gap in research highlights the need for more comprehensive studies that take into account the unique challenges and opportunities faced by teachers in rural regions.

To address this gap, this study focuses on the experiences of teachers in four rural districts in Indonesia. The data were collected through a comprehensive set of questionnaires administered to 616 senior high school teachers. The reliability of the questionnaire was analyzed using the Cronbach Alpha, a widely recognized statistical tool, with the assistance of SPSS software. Descriptive analysis, primarily through the use of percentages, was employed to provide an overview of the data, while inferential statistics were conducted using the Mann-Whitney U-test, as the data did not meet the normal distribution criteria.

Although the study has some limitations, particularly related to sample size, its findings offer valuable insights into the current state of ICT integration in rural schools. The results contribute to the growing body of literature on ICT use in education by providing a unique perspective from underrepresented areas of Indonesia. Moreover, the study serves as an important resource for policymakers and educational practitioners, highlighting the need for

targeted interventions that can improve the readiness of teachers in rural areas to incorporate ICT into their teaching practices.

This research could act as an incentive for further efforts to ensure that all teachers, regardless of their geographical location, are equipped with the necessary skills and resources to use ICT effectively in their classrooms. By doing so, the Indonesian education system can move closer to achieving equitable access to quality education for all students, a key goal in the country's ongoing efforts to enhance educational outcomes and reduce disparities between urban and rural areas (Prasojo et al., 2019).

1.2 Formulation of the Problem

The integration of Information and Communication Technology (ICT) within the Indonesian education system is crucial for aligning with global educational standards and responding to the demands of the Industrial Revolution 4.0. However, several core challenges hinder the effective implementation and utilization of ICT in educational settings. The formulation of the problem in this study is outlined as follows (Mirfani, 2019).

1. Disparity in ICT Implementation Across Regions: Indonesia faces significant disparities in ICT access between urban and rural schools. While urban areas benefit from more robust ICT infrastructure, rural and remote regions often lack the necessary resources such as reliable internet connectivity and modern technological equipment. This imbalance limits the potential benefits of ICT for students and teachers in under-resourced areas, thereby exacerbating educational inequalities.

2. Inadequate Teacher Training and Professional Development: Effective integration of ICT in education depends heavily on the readiness and capability of teachers. Despite efforts to incorporate ICT, many teachers, particularly in rural areas, lack comprehensive training and professional development programs that focus on both the technical and pedagogical aspects of ICT usage. This gap affects their confidence and ability to use technology effectively in the classroom.

3. Low Level of ICT Literacy Among Educational Administrators: The success of ICT implementation is not solely dependent on teachers and students but also on the proficiency of educational administrators. A significant challenge is the low level of ICT literacy among school management and policy implementers, which can hinder the development and execution of effective ICT programs.

4. Limited Integration of ICT in the Curriculum: While the Indonesian education system has made strides in incorporating ICT, it is often treated as a separate subject

rather than being integrated across the curriculum. This limited integration prevents students from experiencing ICT as a supportive tool for learning in various subjects, reducing its potential impact on overall student performance.

5. Insufficient Policy Support and Resource Allocation: Policies supporting ICT integration in education need to be more comprehensive and adaptable to the diverse needs of different regions. Inconsistent policy implementation and insufficient resource allocation contribute to gaps in ICT usage, making it challenging for schools, especially those in rural areas, to sustain ICT programs.

6. Challenges in Keeping Up with Technological Advancements: The rapid pace of technological change requires continuous updates and maintenance of ICT infrastructure and tools. Many schools struggle to keep up with these advancements, leading to outdated equipment and limited access to modern ICT solutions. This challenge affects the quality of ICT-based teaching and learning and impedes students' ability to develop relevant digital skills.

7. Social and Cultural Barriers to ICT Adoption: The integration of ICT also faces social and cultural resistance in certain regions, where traditional teaching methods are deeply ingrained. These barriers can prevent both teachers and students from fully embracing ICT as an effective educational tool.

1.3 Scope of Problem

The integration of Information and Communication Technology (ICT) in the educational system, particularly within the Ministry of Education in Indonesia, has shown great potential yet faces several complex challenges. This research focuses on the following key areas within the scope of ICT impact and challenges in Indonesian education:

1. Impact of COVID-19 on ICT in Education: The global COVID-19 pandemic forced educational institutions to adapt rapidly to new methods of teaching and learning. Students were required to study from home, and teachers had to implement online classes. This abrupt transition highlighted the need for robust ICT infrastructure and tools to support remote learning. The pandemic exposed gaps in the readiness of schools and teachers to adapt to digital teaching, emphasizing the necessity for sustainable e-learning solutions and teacher preparedness.

2. Teaching Strategies and Challenges: During the pandemic, three main teaching strategies were employed: using online chat platforms, conducting video conferences, and

combining both methods. Each strategy posed challenges, such as teachers' limited access to technology, insufficient school facilities, and difficulties in explaining material through digital means. These challenges were compounded by teachers' varying levels of technological proficiency and the lack of consistent training in using ICT tools effectively.

3. Internet Access and Infrastructure Limitations: One of the most significant obstacles to ICT integration is the unequal distribution of infrastructure, particularly between urban and rural areas. Schools in rural regions face issues such as unreliable internet connectivity, outdated equipment, and limited technical support. These disparities hinder the equitable implementation of ICT and prevent students from accessing the same educational opportunities as those in more developed areas.

4. Economic and Social Barriers: Students' socioeconomic backgrounds also play a crucial role in the effectiveness of ICT implementation. Many students from economically disadvantaged families struggle to access the necessary resources for online learning, such as computers or reliable internet connections. This limitation further widens the educational gap between different communities and poses a challenge to achieving equal educational opportunities for all students.

5. Teacher Training and Technological Preparedness: The effectiveness of ICT in education heavily depends on the knowledge and skills of teachers. In many cases, teachers have not received sufficient training to incorporate ICT into their teaching practices effectively. This lack of training results in a reluctance to adopt new technologies and reduces the overall impact of ICT on learning outcomes. Comprehensive teacher training programs focusing on both technical skills and pedagogical approaches to ICT use are essential for the successful integration of digital tools in classrooms.

6. Policy and Management Challenges: The rapid shift to online learning during the COVID-19 outbreak required educational institutions to develop new management and operational strategies. However, the absence of cohesive policies and clear guidelines often left schools struggling to support both students and teachers adequately. Effective policies that address infrastructure development, teacher support, and resource allocation are crucial to overcoming these management challenges.

7. Educational Inequality and the Digital Divide: The disparity in ICT access between urban and rural schools exacerbates educational inequality. While urban schools may benefit from better infrastructure and resources, rural schools often lack the basic tools needed for digital learning. This digital divide limits the impact of ICT on

student performance and perpetuates the gap in educational quality across different regions.

8. Need for Culturally and Regionally Adaptable Content: The development of digital learning materials that resonate with local cultures and languages is critical. Current ICT initiatives often overlook the need for content that is adaptable to the diverse cultural landscape of Indonesia. Ensuring that digital resources are inclusive and relevant to different regions can enhance the effectiveness of ICT in education and promote more widespread adoption.
9. Parental Support and Home Learning Environment: The success of ICT in home-based learning also depends on the support systems available to students. Parents' involvement and their ability to facilitate learning at home play a significant role. The lack of parental support, often due to limited technological knowledge or time constraints, can hinder students' ability to engage effectively in online learning.
10. Recommendations for Future Research and Implementation: The findings from this study highlight the importance of ongoing research to address the challenges identified. Future research should focus on developing targeted solutions for ICT implementation in rural areas, improving teacher training programs, and creating policies that promote equitable access to technology. Continuous evaluation and refinement of ICT initiatives are necessary to build a resilient and adaptive education system.

1.4 Research Purposes

The purpose of this research is to explore and analyze the impact of Information and Communication Technology (ICT) on teachers' and students' performance within the Ministry of Education in Indonesia. The study aims to address the following specific objectives:

1. Evaluate the impact of ICT on teaching effectiveness: Investigate how the integration of ICT influences teachers' instructional methods, effectiveness, and adaptability in the classroom. This includes assessing whether ICT facilitates more interactive and engaging teaching practices and supports diverse pedagogical approaches.
2. Examine the influence of ICT on student learning outcomes: Analyze the ways in which ICT affects students' academic performance, engagement, and overall learning experience. The objective is to determine if the use of digital tools and resources leads to improved comprehension, participation, and academic achievements.

3. Identify challenges in ICT implementation: Highlight the key challenges teachers and students face in the adoption and utilization of ICT within educational settings, particularly focusing on infrastructure limitations, resource availability, and technical support. This aims to provide a comprehensive understanding of the barriers that hinder the effective use of ICT.

4. Assess teachers' preparedness and professional development needs: Examine the current state of teacher training and professional development programs related to ICT. The goal is to identify gaps in training that affect teachers' ability to effectively incorporate ICT into their teaching practices and propose strategies for continuous professional growth.

5. Explore regional disparities in ICT access and utilization: Investigate the differences in ICT access and utilization between urban and rural schools to highlight the digital divide within Indonesia's educational system. This aims to provide insights into how geographical disparities impact the implementation and effectiveness of ICT in education.

6. Develop recommendations for policy and practice: Propose strategic recommendations for educational policymakers and practitioners to enhance ICT integration in a way that supports teaching and learning. This includes suggesting policy measures, infrastructure improvements, and region-specific approaches to address the diverse educational needs across Indonesia.

1.5 Benefits of Research

The present study explores the influence of ICT at the school level in Indonesia, highlighting its impact beyond educational settings to include social and economic aspects. The research findings are anticipated to provide significant benefits, including but not limited to:

1. Understanding ICT's role in academic success: This research helps identify the major causes behind students' academic challenges related to accessing and utilizing ICT, allowing educational stakeholders to address these issues more effectively.

2. Identifying barriers to ICT integration: The study will shed light on the specific challenges faced by teachers and students in integrating ICT into their teaching and learning processes, particularly in under-resourced schools.

3. Providing solutions for educational challenges: By examining current strategies and

identifying gaps, the research aims to offer practical solutions to the challenges students face in accessing and benefiting from ICT.

4. Informing policy and strategic planning: The findings will serve as a valuable resource for policymakers and educational administrators, aiding in the development of more effective policies and strategic plans to enhance ICT usage in education.
5. Promoting professional development: The study emphasizes the importance of teacher training and professional development in successful ICT integration. Insights from this research could encourage investment in teacher development programs to enhance teaching quality and student outcomes.
6. Supporting economic and social growth: By improving ICT integration at the school level, the research underscores the potential for long-term economic and social benefits, fostering a more skilled and technologically proficient workforce in Indonesia.
7. Identifying barriers to ICT integration: The study will shed light on the specific challenges faced by teachers and students in integrating ICT into their teaching and learning processes, particularly in under-resourced schools.
8. Providing solutions for educational challenges: By examining current strategies and identifying gaps, the research aims to offer practical solutions to the challenges students face in accessing and benefiting from ICT.
9. Informing policy and strategic planning: The findings will serve as a valuable resource for policymakers and educational administrators, aiding in the development of more effective policies and strategic plans to enhance ICT usage in education.
10. Promoting professional development: The study emphasizes the importance of teacher training and professional development in successful ICT integration. Insights from this research could encourage investment in teacher development programs to enhance teaching quality and student outcomes.
11. Supporting economic and social growth: By improving ICT integration at the school level, the research underscores the potential for long-term economic and social benefits, fostering a more skilled and technologically proficient workforce in Indonesia.

The insights gained from this study will contribute to the broader discourse on ICT integration in education, offering a foundation for future research and strategic decisions aimed at optimizing the use of ICT to improve teaching and learning experiences.

II. LITERATURE REVIEW

2.1 Teaching Strategies

The evolution of online education has increasingly emphasized the importance of adopting instructional strategies that are inherently student-centered. This approach ensures that the educational experience is tailored to the unique needs and learning styles of students and fosters a more personalized and effective learning environment. In online courses, where face-to-face interaction is limited, it becomes even more important to design content and activities that actively engage students and promote their participation in the learning process. A key strategy in achieving this is through peer collaboration, which not only increases learning outcomes, but also creates a sense of community among students and helps reduce the isolation that can sometimes accompany online learning (Garrison & Vaughan, 2008).

Collaborative activities are most effective when they are structured with clear guidelines and rubrics that detail the criteria for engagement and participation. These rubrics provide students with a road map for meaningful participation and ensure that all group members are engaged in the learning process. In addition, these activities promote critical thinking, problem solving, and the application of knowledge in a practical context, which are essential skills in both academic and professional settings.

In addition to collaborative elements, the integration of reflective activities is a critical component in effective online course design. Reflective activities encourage students to think deeply about what they are learning, connect it to their existing knowledge and experience, and consider its application to real-world scenarios. This reflective practice not only deepens understanding, but also helps students develop the meta cognitive skills necessary for lifelong learning.

In addition, it is critical to incorporate clear assessment criteria into online learning. Clear and well-defined assessment standards help students understand what is expected of them, guide their learning efforts, and reduce anxiety associated with the assessment process. These criteria also allow for more consistent and fair scoring, which is especially important in an environment where direct interaction with instructors is limited (Garrison

and Vaughan, 2008) (Garrison & Vaughn, 2008).

Technology integration is another cornerstone of successful online course design. The use of multimedia tools, interactive content and digital resources can significantly increase the learning experience by considering different learning styles and making abstract concepts more concrete. For example, videos, simulations, and interactive modules can bring complex theories to life and make them more accessible and engaging for students. In addition, the use of technology facilitates a more flexible learning environment and allows students to access materials and activities at their own pace, which is especially important for adult learners who may be balancing their studies with work and family responsibilities. is useful (Mayer, 2009) (Mayer, 2009).

The concept of course redesign is a powerful strategy for moving traditional face-to-face courses to an online format. Course redesign involves revising and restructuring course content, delivery methods, and assessment strategies to take advantage of the unique benefits of online learning. One of the primary benefits of course redesign is its potential to reduce costs and increase student retention rates. By creating a more engaging and supportive learning environment, course redesign can help retain students who might otherwise drop out due to lack of motivation or support. In line with the principles of androgyny, course redesign strategies emphasize the use of interactive and student-centered learning approaches in online settings. These strategies include integrating multimedia tools, such as online tutorials and automated feedback systems that provide students with immediate, personalized responses to their work. Small discussion groups and a supportive learning community help students master course content by providing opportunities for interaction, feedback, and collaboration. While the online environment differs from traditional classrooms, many of the best practices for teaching remain the same. These include promoting peer-to-peer interaction, encouraging active student participation, emphasizing the importance of practice and effort, and providing a variety of learning activities that accommodate different learning styles. Additionally, effective online courses should emphasize higher-order thinking skills, such as analysis, synthesis, and evaluation, to challenge students and foster deeper learning.

However, online instruction presents unique challenges that require instructors to adopt additional strategies not typically necessary in face-to-face courses. For example, while online courses often follow an asynchronous model, it is important to incorporate synchronous activities, such as live discussions or collaborative projects, to create a sense of immediacy and interaction. Co-curricular activities help bridge the gap created by the lack of physical presence and foster a more interactive and relevant learning experience (Mayer, 2009).

Instructors should also be aware of the varying levels of technical proficiency among students. Assumptions about students' abilities to navigate digital platforms and tools

can lead to frustration and disengagement. Therefore, it is essential to provide adequate technical support, training, and resources to ensure that all students can fully participate in the online course. This support is especially important for students who may be less familiar with the technology or do not have access to the Internet and reliable devices.

2.2 Teaching Problems

The integration of information and communication technology (ICT) in education has become the main focus of many education systems around the world, including Indonesia. The promise of information and communication technology lies in its potential to transform the learning experience, making education more accessible, interactive and tailored to the needs of students. However, the transition from traditional face-to-face teaching methods to ICT-supported environments is fraught with challenges that educators, administrators, and policy makers must address to realize these benefits. These challenges are particularly acute in areas such as the Indonesian Ministry of Education, where ICT adoption is still in its infancy and infrastructure, training and organizational support are often lacking.

One of the most important challenges in integrating ICT in education is the difficulty of effectively transferring traditional teaching methods to the online environment. (Anderson et al., 2011) Anderson, Imdike, and Standerford (2011) highlighted an important issue in the "disconnect between teachers' teaching methods" and the requirements for effective online education. This disconnect is particularly evident in educational systems such as Indonesia, where many teacher education programs have yet to fully include training on how to use ICT tools effectively. As a result, educators often find themselves unprepared for the demands of digital education, which can lead to reduced teaching effectiveness and reduced student performance.

This challenge is exacerbated by the fact that many instructors are trained primarily for face-to-face instruction, which relies heavily on direct interaction and the ability to gauge student understanding through nonverbal cues and immediate feedback. In an online environment, these traditional methods of engagement are often unavailable, requiring teachers to develop new strategies to maintain student interest and engagement. However, without adequate training in these new methodologies, many educators struggle to adapt, leading to a potential reduction in the quality of education provided through ICT platforms.

In addition, the lack of clear organizational expectations and guidelines for the use of ICT in education exacerbates this problem. Anderson et al. (2011) noted that many educational institutions, including educational institutions in Indonesia, have not developed comprehensive frameworks that outline the roles and responsibilities of teachers, students,

and administrative staff in IT-supported environments. and define communication. This lack of clear guidelines can lead to inconsistencies in how ICT is implemented in different schools and classrooms, leading to different levels of effectiveness and student outcomes. For example, some teachers may enthusiastically use ICT and integrate it seamlessly into their teaching practices, while others may resist or struggle with the technology. , leading to a disjointed and uneven educational experience for students. In addition to the lack of institutional support, feedback mechanisms in advanced ICT education pose significant challenges. In traditional face-to-face settings, teachers can easily assess student understanding through direct interaction, allowing them to adjust their teaching strategies in real time. However, in ICT-supported environments, this immediate feedback loop is often disrupted. (Anderson et al., 2011) As Anderson et al. (2011) observed, feedback received from students in online settings often lacks the immediacy and depth required for real-time instructional settings. This is particularly problematic in asynchronous learning environments, where the time lag between student responses and teacher feedback can hinder the learning process and reduce the overall effectiveness of instruction. How to deliver content in an ICT-supported learning environment also presents unique challenges that differ significantly from traditional classroom environments. Educators are required to examine not only interactions between students and teachers, but also interactions between students and their peers, as well as between students and technology. This shift in the instructor's role—from a primary source of knowledge to facilitating a multifaceted learning environment—requires significant support from technology and curriculum developers. Feign and Logan (2013) emphasized that effective ICT integration depends on seamless collaboration between these stakeholders to ensure that the technological tools used in classrooms support educational goals.

The complexities of integrating ICT extend beyond the classroom and into the wider education system. For example, changes in the way learning management systems (LMS) manage interactions and deliver content can create additional barriers for educators and students. LMSs are the backbone of most ICT-enabled learning environments, providing a platform through which courses are delivered, assignments are managed, and communication is facilitated. However, not all LMSs are created equal, and differences in functionality, user interface, and technical support can significantly impact the user experience. Instructors who are not well-versed in the particular LMS in use may find it difficult to effectively manage their courses, while students may struggle to navigate the system, leading to frustration and disengagement.

In addition, reliance on technology introduces challenges related to access and skills, especially in areas with limited infrastructure, such as rural areas in Indonesia. In these contexts, reliable Internet access and up-to-date hardware can be significant barriers to

effective ICT integration. Students who do not have access to these resources are at a disadvantage compared to their peers in more urban areas, which exacerbates educational inequalities. Furthermore, even when the necessary technology is available, both educators and students may lack the digital literacy skills needed to use it effectively. This digital divide can lead to inappropriate content delivery, while some students struggle to meet online learning needs due to insufficient technological skills or resources. The challenges of ICT integration also extend to curriculum content design and development. Traditional teaching materials, such as textbooks and lectures, are not always suitable for the online environment and may need to be revised to take full advantage of ICT capabilities. This process of redesigning curriculum content to fit an ICT-supported framework can be resource-intensive, requiring time, expertise, and collaboration between educators, instructional designers, and technology specialists. In addition, the rapid pace of technological change means that curriculum content must be constantly updated to remain relevant and effective, adding an additional layer of complexity.

In the context of the Indonesian Ministry of Education, these challenges are compounded by the need to ensure that ICT integration is aligned with national educational goals and standards. The ministry has set ambitious goals for improving educational outcomes through the use of information and communication technology, but achieving these goals requires a coordinated effort at all levels of the education system. This includes not only providing the necessary infrastructure and training, but also developing policies and frameworks that support the effective use of ICT in teaching and learning. Without this systemic approach, the potential benefits of ICT may remain unrealized as students and teachers alike struggle to adapt to the new educational landscape. Educators play an important role in this adaptation process, but they cannot do it alone. The success of ICT integration depends on the availability of professional development opportunities that equip teachers with the skills and knowledge needed to use technology effectively. This professional development must continue, given that ICT is a rapidly developing field and teachers must constantly update their skills to keep pace with new developments. In addition, professional development should be tailored to the specific needs of educators in different contexts, recognizing that the challenges of teachers in rural Indonesia may differ significantly from those in urban areas.

Furthermore, the role of leadership in facilitating ICT integration cannot be overstated. School leaders, including principals and principals, are instrumental in creating a culture that supports the use of ICT in education. They are responsible for setting the vision and expectations for ICT use, providing necessary resources and support, and creating an environment in which teachers feel confident in experimenting with new technologies and

approaches. Effective leadership is also critical in ensuring that the integration of ICT is aligned with the wider aims of the school and contributes to the overall improvement of educational outcomes.

Furthermore, the impact of ICT on student performance does not depend only on the technology itself, but also on how it is integrated into the learning process. Research has shown that simply introducing technology into the classroom is not enough to improve student outcomes. It should be used in a way that actively engages students and supports meaningful learning experiences. This requires a change in teaching methods, moving away from traditional and lecture-based approaches to more interactive and student-centered methods that use ICT capabilities. However, making this change can be challenging for teachers who are used to more traditional methods and may be unsure of how to effectively use technology in their teaching.

Ultimately, the success of integrating ICT in education depends on the ability of all stakeholders—teachers, students, administrators, policymakers, and technology providers—to work together toward a common goal. This collaborative approach is necessary to overcome the challenges associated with ICT and to ensure that its potential benefits are fully realized. In the context of the Indonesian Ministry of Education, this means developing policies and frameworks that support the effective use of ICT, providing the necessary resources and training, and fostering a culture of innovation and experimentation in the classroom.

Consequently, while the integration of information and communication technology in education holds promise, it also presents significant challenges that must be addressed to ensure its success. These challenges are multifaceted and include not only technical issues but also educational, institutional and systemic factors. In the context of the Indonesian Ministry of Education, addressing these challenges requires a coordinated effort at all levels of the education system, from policymakers to classroom teachers. By providing the necessary support, training, and resources, and by fostering a culture of collaboration and innovation, these challenges can be overcome and the full potential of information and communication technology used in improving educational outcomes for all students.

2.3 E-learning

The implementation of e-learning systems has become increasingly necessary in modern education, especially in the context of the Indonesian Ministry of Education. E-learning is basically mixed with the concepts of "internet" and "technology" which act as the backbone of this digital educational approach. In the era of Industry 4.0, where digital transformation is crucial, teachers are required to master Internet-based technologies to effectively enhance

their teaching practices. Integrating traditional traditional education with e-learning tools, often referred to as blended learning, is critical in modernizing education. This approach has become more relevant in light of the COVID-19 pandemic, which has necessitated changes to distance learning environments, forcing educational institutions to adopt a "study from home" model almost overnight.

In the field of e-learning, various information and communication technology (ICT) tools have been used to effectively support online classrooms. Among these tools, WhatsApp has emerged as a popular and widely used application. As a free messaging app, WhatsApp provides an accessible platform for communication between teachers and students. Its simplicity and universality make it an effective tool for increasing learning outcomes, fostering positive student attitudes toward the learning process, and improving student motivation (Santos, 2020). WhatsApp also plays an important role in peer assessment and is considered a valid and reliable tool to facilitate student interactions and feedback. However, despite its advantages, WhatsApp is sometimes seen by educators as limited in its ability to directly influence teaching methods, and is often used mainly for document management and basic communication rather than a comprehensive teaching tool.

Google Classroom is another popular platform in the e-learning ecosystem. This free software is specifically designed to help teachers manage classroom activities, communicate with students, and conduct online lessons more efficiently. Google Classroom allows teachers to simplify assigning assignments, collecting student work, and providing feedback, making it a valuable tool for both teachers and students. However, some challenges are associated with its use, especially in contexts such as Indonesia, where access to technology and the Internet can be contradictory (Alim et al., 2019). For example, effective use of Google Classroom for smartphones and mobile data may present significant barriers for students from disadvantaged backgrounds. Additionally, some educators found that while Google Classroom was effective in managing classroom logistics, it did not necessarily change teaching practices or increase student engagement by itself. YouTube offers another powerful tool in the e-learning landscape, offering a vast repository of educational videos that can be integrated into educational practices. Using YouTube videos in the classroom provides flexibility in teaching and allows teachers to present content in a dynamic and engaging manner (Moghavvemi et al., 2018). This approach not only helps explain complex concepts, but also supports different learning styles by providing visual and auditory learning opportunities. YouTube has been shown to have a significant impact on students' understanding of content, making it a valuable resource for educators aiming to increase the effectiveness of instruction. Additionally, YouTube's accessibility and ability to review content at any time make it a valuable tool for enhancing learning outside of the traditional classroom en-

vironment. In addition to WhatsApp, Google Classroom and YouTube, other applications such as ZOOM, Google Meet and Facebook are increasingly used to support online education. ZOOM and Google Meet have become indispensable tools for conducting live virtual classes that enable real-time interaction between teachers and students, helping to bridge the gap created by the lack of physical presence in an online environment. These platforms facilitate synchronous learning, where students can participate in discussions, ask questions, and receive immediate feedback, thereby creating a more interactive and engaging learning environment. Facebook also plays a role in e-learning by providing a platform for creating study groups, sharing resources, and fostering community among students.

However, the decision to choose appropriate e-learning tools should be made by considering factors such as teachers' mastery of technology, access and students' familiarity with the tools and the overall technological infrastructure in the area. In the context of the Indonesian Ministry of Education, these considerations are particularly important due to the diverse range of socio-economic conditions and different levels of access to technology in different regions. The successful implementation of e-learning requires a supportive ecosystem that includes not only the right tools, but also the necessary training and resources for teachers and students(Alim et al., 2019).

Furthermore, the use of these tools should not be seen as a mere means of replicating traditional classroom experiences, but as an opportunity to transform the teaching and learning process. E-learning offers the potential to create more personalized and flexible learning environments that meet the individual needs of students. By taking advantage of the strengths of various ICT tools, educators can design learning experiences that are more engaging, interactive, and effective. However, this requires a change of mindset from simply using technology to enhance traditional methods to adopting new educational approaches that fully exploit the capabilities of digital tools (Moghavvemi et al., 2018).

Furthermore, the use of e-learning tools has significant implications for educational equity. In Indonesia, where there are disparities in access to technology and Internet connectivity, especially in rural and underprivileged areas, the adoption of e-learning tools should be accompanied by efforts to bridge the digital divide. This includes not only providing students with the necessary devices and Internet access, but also ensuring that teachers are equipped with the skills and knowledge to use these tools effectively. Additionally, there should be a focus on developing culturally relevant content that resonates with students from diverse backgrounds and further increases the accessibility and effectiveness of e-learning.

As a result, the integration of e-learning in the education system in Indonesia, especially in the Ministry of Education, presents challenges and opportunities. While there are significant obstacles to overcome, such as disparities in access to technology and the need

for ongoing professional development for educators, the potential benefits of e-learning are significant. By carefully selecting and implementing the right tools, and by providing the necessary support for teachers and students, e-learning can play a central role in improving educational outcomes and ensuring that education remains accessible and effective in the digital age.

2.4 ICT Plays a Role in Student's Achievement:

The role of information and communication technology (ICT) in enhancing student achievement in the Indonesian Ministry of Education is profound and multifaceted. Integrating information and communication technology into educational settings is critical, especially at the school level, where access to computers and electronic devices significantly affects student learning outcomes. The presence of information and communication technology tools, such as computers, tablets and smart phones, enables students to learn more efficiently and effectively compared to their peers who do not have access to these technologies. This access to technology provides opportunities for students to engage with interactive learning materials, research, and develop critical thinking skills, all of which contribute to improved academic performance.

Information and communication technology has revolutionized educational practices by changing educational and administrative processes. In classrooms equipped with information and communication technology, students are no longer passive recipients of information, but active participants in their learning journey. For example, interactive software and educational games can adapt to a student's learning pace, provide immediate feedback, and allow for personalized learning experiences. This level of engagement is difficult to achieve in traditional classroom environments without the aid of technology.

The use of information and communication technology also allows the integration of multimedia resources into the curriculum. Teachers can incorporate videos, animations and simulations into their lessons and make complex concepts more understandable and engaging. This multimedia approach responds to different learning styles, whether visual, auditory or anesthetic, thereby enhancing the overall learning experience. For example, science lessons can be enriched with virtual experiments, where students can manipulate variables and see results in real time, something that would be challenging or impossible in a traditional classroom without ICT. .

One of the most important effects of information and communication technology is its ability to simplify and improve administrative functions in schools. For example, using common office automation software, such as Microsoft Office or Google Workspace, allows

schools to maintain accurate records of student performance and progress. This digital record keeping not only improves the efficiency of administrative tasks, but also provides teachers with valuable data that can be used to adjust instruction to meet the needs of each student. This data-driven approach ensures that teachers can identify students who may be struggling and intervene early, thereby improving student outcomes over time. In addition, the availability of educational materials and textbooks in electronic form has revolutionized the way students access and interact with educational content. Digital textbooks and e-learning resources allow students to access a wealth of information at the click of a button, making learning more flexible and personalized. This access is especially useful in Indonesia, where students in remote or undeserved areas may face challenges in obtaining physical textbooks. By providing electronic access to educational materials, ICT helps bridge the gap between urban and rural students and promotes educational equity across the country. The ability to quickly update electronic resources also means that students have access to the most up-to-date information, which is crucial in a rapidly changing world. It has also been shown that the continuous use of ICT in the classroom has a positive effect on student motivation. According to the research of (Balanskat et al., 2007) and (Becerra, 2010), the integration of ICT in educational practices leads to increased student participation and sustained interest in learning. This increased motivation is largely due to the interactive and dynamic nature of digital learning tools that can make learning more enjoyable and relevant to students' lives. For example, multimedia presentations, educational games, and interactive simulations provide students with hands-on learning experiences that are both engaging and educational.

In addition, ICT enables students to develop essential 21st century skills such as digital literacy, problem solving and collaboration. These skills are increasingly important in today's globalized world where technology plays a central role in almost every aspect of life. By integrating ICT into the curriculum, schools not only increase academic achievement, but also prepare students for future success in the workforce. This alignment of education with the demands of the modern economy emphasizes the critical importance of information and communication technology in enhancing student achievement.

However, it is important to note that successful integration of ICT in schools requires adequate infrastructure, training and support. The effectiveness of ICT in improving student achievement depends on reliable Internet access, up-to-date hardware and software, and trained instructors who are confident in using technology to enhance learning. In Indonesia, where there are differences in access to technology between urban and rural areas, addressing these challenges is essential to ensure that all students enjoy the benefits of ICT.

For example, rural schools may lack the necessary infrastructure such as stable Internet

connections or sufficient power supply to support the effective use of ICT. These restrictions can prevent the implementation of education based on information and communication technology and intensify existing educational inequalities. To reduce these challenges, the government and educational institutions should prioritize investment in ICT infrastructure and support schools in disadvantaged areas.

As a result, ICT plays a fundamental role in enhancing student achievement in the Indonesian Ministry of Education. Information and communication technology facilitates more efficient and effective learning by providing students with access to computers, electronic devices, and digital learning resources. Additionally, the use of ICT in the classroom promotes motivation, engagement, and the development of critical skills necessary for success in the 21st century. To fully realize the benefits of ICT, it is essential to ensure that the necessary infrastructure, training and support are in place so that all students, regardless of their location or socio-economic background, can use these transformation tools.

2.5 Use of Multimedia in Education

In today's rapidly evolving digital landscape, the integration of multimedia in education has become not just an option, but a necessity for enhancing the learning experience. Multimedia refers to the combination of various forms of content such as text, images, audio, video, and interactive elements, all of which can be used to deliver information in dynamic and engaging ways. This approach moves beyond traditional lecture-based teaching, making learning more interactive, engaging, and effective.

1. Transforming the Learning Environment

   In Indonesian schools, the use of multimedia has been particularly impactful. According to research by Mahdum et al. (Mahdum et al., 2019), teachers who incorporate multimedia into their lessons have noticed a significant increase in student engagement. When students are exposed to multimedia resources—such as educational videos, animations, and interactive simulations—they tend to be more attentive, motivated, and enthusiastic about learning. This is especially true for subjects that are typically challenging, such as mathematics or science. By breaking down complex concepts into visual or interactive elements, multimedia helps make difficult topics more accessible and understandable.

   Teachers in Indonesia, as highlighted by Mahdum et al. (Mahdum et al., 2019), have found that the use of ICT, including multimedia tools, allows for more flexibility in their teaching strategies. For instance, a teacher might use an animation to explain a

scientific process or employ an educational game to teach grammar. These tools not only enhance comprehension but also make the classroom experience more enjoyable, which is crucial in maintaining student interest.

2. Benefits Beyond Engagement: Addressing Learning Barriers

   Prasojo et al. (Prasojo et al., 2019) emphasize that multimedia in education goes beyond just making lessons more exciting—it actively helps in overcoming educational barriers. In many Indonesian classrooms, where resources may be limited and student backgrounds diverse, multimedia can bridge gaps in understanding by catering to various learning styles.

   Some key benefits of using multimedia in education include:

   (a) Catering to Diverse Learning Styles: Students who struggle with reading-heavy content might benefit from audio explanations or visual aids. This inclusivity ensures that all students, regardless of their learning preferences, have the opportunity to grasp the material effectively.

   (b) Supporting Differentiated Learning: Multimedia allows teachers to tailor content to meet individual student needs. By providing supplementary materials, students can explore content at their own pace, promoting self-directed learning and a deeper understanding of subjects.

   (c) Enhancing Engagement and Motivation: By making lessons more dynamic and interactive, multimedia helps to sustain students' attention and motivation, ultimately leading to improved academic performance.

3. The Role of Multimedia During the Pandemic

   The onset of the COVID-19 pandemic forced educators worldwide to rethink their teaching methods, and Indonesia was no exception. As schools transitioned to online learning, the reliance on multimedia became more pronounced. According to Prasojo et al. (Prasojo et al., 2019), the use of multimedia tools during this period was crucial in maintaining student engagement despite the challenges of remote education.

   (a) Maintaining Student Interaction: Multimedia content, such as recorded lectures and virtual simulations, helped teachers maintain a connection with their students even in a remote setting.

   (b) Facilitating Asynchronous Learning: By leveraging multimedia, educators could provide recorded content that students could access at any time, allowing for flexible learning schedules.

(c) Creating a Sense of Presence: The use of multimedia tools in live sessions, like video tutorials followed by discussions, helped replicate the classroom experience, thus reducing the sense of isolation during remote learning.

4. The Future of Education with Multimedia

   As Indonesia continues to modernize its education system, the role of multimedia will only grow in importance. By integrating multimedia resources, educators can create a more inclusive, engaging, and effective learning environment. The research by Mahdum et al. (Mahdum et al., 2019) and Prasojo et al. (Prasojo et al., 2019) highlights how multimedia not only enhances student motivation but also addresses learning challenges, paving the way for a more resilient and adaptive education system in the digital age.

2.6 The Effectiveness of Online Learning Using Zoom Meetings and Other Apps at Elementary Schools

Digital literacy, as defined by Paul Gilster in his seminal work *Digital Literacy* (1997), is the ability to comprehend and utilize information in various formats from a broad range of sources accessed through digital technologies. During the COVID-19 pandemic, elementary school pupils in Indonesia were introduced to digital literacy as a critical skill. In today's globalized world, teachers play an essential role in setting a positive example for students, especially when it comes to fostering a reading culture. Teachers who demonstrate a habit of reading—whether in the school library or their offices—can inspire students to develop a love for reading. This literacy culture is deeply interconnected with education, as the mastery of literacy is often seen as a key factor in the success of the younger generation.

The Indonesian Ministry of Education, led by Nadiem Anwar Makarim, has developed a national educational platform designed to facilitate interaction, learning, and collaboration among teachers and students across the country (Mahdum et al., 2019). This initiative aims to optimize the use of technology to ensure that educational services reach children, especially during challenging times like the COVID-19 pandemic. The application of technology needs to be both targeted and competent—meaning it should address the challenges of the education system, particularly in terms of quality learning and access to education (Kemdikbud, 2021).

1. The Shift to Online Learning

   The COVID-19 pandemic drastically altered educational patterns, shifting from tra-

ditional face-to-face learning to online platforms. This sudden change was necessary to prevent the spread of the virus, which led to social restrictions and the temporary cessation of in-person classes. As a result, online learning became a vital tool in maintaining educational continuity. According to Smaldino, Lowther, and Mims (**?**), learning activities in the digital era can effectively occur both inside and outside the classroom using computer-based technologies that are easily accessible.

The Indonesian government has implemented an online learning policy to adapt to these changes, emphasizing the need for digital platforms to ensure continuous learning. Schools have adopted platforms like Zoom Meetings, Google Classroom, and Microsoft Teams to facilitate remote education. The benefits of online learning include flexibility, accessibility, and the ability to engage students in interactive ways that may not be possible in traditional classroom settings.

2. Benefits of Online Learning Platforms

   Online learning platforms, such as Zoom Meetings, have been widely used in Indonesia during the pandemic. These platforms offer several advantages, including:

   (a) Flexibility and Accessibility: Online platforms enable students to attend classes from anywhere, breaking the barriers of time and location. This flexibility has been crucial in ensuring that students continue learning even during lockdowns.

   (b) Increased Engagement: Tools like Zoom offer features such as screen sharing, breakout rooms, and real-time chat, which can enhance student interaction and engagement.

   (c) Effective Use of Multimedia: Online platforms allow teachers to incorporate multimedia elements—videos, animations, and interactive content—into their lessons, which can help students better understand complex topics and stay motivated.

2.7 E-mail and WhatsApp Used by Teachers and Students

In today's digital world, communication tools like email and WhatsApp have become essential for enhancing communication between teachers and students. These platforms are widely used across all levels of education, allowing teachers to reach students quickly and efficiently. By using email and WhatsApp, educators can share updates, assignments, and

important resources directly with their students, ensuring that no one misses critical information, especially in situations where face-to-face interactions are limited.

The shift towards using these platforms has proven particularly effective during the COVID-19 pandemic, where traditional classroom settings were disrupted. With the help of WhatsApp and email, teachers have been able to maintain an ongoing dialogue with their students, keeping them informed about assignments, upcoming lessons, and learning resources. This easy access to information has streamlined the educational process and provided students with a sense of continuity during uncertain times.

1. Enhancing Communication:

   Emails and WhatsApp allow for instant communication between teachers and students. By sending messages, teachers can quickly inform students about changes in schedules, assignments, or upcoming tests. This immediate feedback loop helps students stay on track with their studies.

2. Supporting Student Engagement:

   These communication tools enable teachers to share educational content beyond the classroom walls. For example, they can send study materials, video tutorials, and additional resources that encourage students to explore topics on their own. WhatsApp, in particular, supports group discussions, allowing students to collaborate and share ideas, which can lead to a deeper understanding of the subject matter.

3. Developing Digital Literacy Skills:

   As students frequently use these platforms to receive updates and complete assignments, they naturally develop important digital literacy skills. Learning to communicate effectively via email, managing digital files, and collaborating in group chats are skills that are increasingly valuable in today's digital landscape.

4. Flexibility and Accessibility:

   One of the key advantages of using WhatsApp and email is the flexibility they offer. Students can access learning materials anytime, anywhere, which is especially helpful for those who may have other responsibilities or limited access to physical classrooms. This flexibility is crucial, particularly in remote or underserved areas where internet access might be inconsistent.

5. Encouraging Self-Directed Learning:

   By providing students with resources through emails and WhatsApp, teachers empower them to take charge of their own learning. Students can review materials at

their own pace, revisit past lessons, and ask questions whenever they need clarification. This encourages a proactive approach to education, where students learn to manage their time and resources effectively.

Challenges and Considerations:

1. Limited access to technology can create a gap in communication, as not all students may have reliable internet or smartphones.
2. The constant use of WhatsApp for academic communication can blur the lines between school time and personal time, potentially leading to burnout for both students and teachers.
3. Teachers should be mindful of the frequency of messages to avoid overwhelming students. Striking a balance is essential to ensure that communication remains effective without causing stress.

in summary The use of email and WhatsApp by teachers and students has transformed the way educational content is delivered, making communication more efficient and flexible. As these tools continue to play a pivotal role in education, especially in times of crisis, they will likely remain a key part of the learning environment. By effectively using these platforms, educators can ensure that their students stay connected, engaged, and motivated to succeed in their studies.

III. RESEARCH METHODOLOGY

3.1 Type of Research

The Qualitative research method used for this study, in this study, I reviewed the available and related articles to the research subject and objectives reviewed the recent article from the year of 2000-2020

3.2 Development Procedures

Nowadays, the fast-shifting of the technological trend has affected Indonesia education, such a shifting of teaching and learning process from the conventional model into open education. This phenomenon makes the Indonesian government realize that technology integration in the educational program has an important role in creating a strong society for global competition. The plan and development of technology for education was regulated in UU Sisdiknas No 20 the Year 2003 chapter 36 which states one of the provisions in curriculum design must be following the development of science, technology, and art. There are many more national constitutions of Indonesia that are regulating the technology implementation for educational purposes. For example, the regulation of the Ministry of Administrative and Bureaucratic Reform No 28 2017 chapter 6B which explained about the provision in developing technology for learning purposes. As the biggest archipelago country in ASEAN, the major issue for Indonesia education is the inequity of educational access, especially in the remote and border area. Taking this issue into consideration, The Indonesian government has introduced a famous educational program through television broadcast known as TV Edukasi (TV-E) which was aired in October 2004. This program is aiming to support educational access equity, quality improvement of education, and support of 9-year compulsory basic education [26]. In the same year, the national program IGOS (Indonesia Go Open Source) was released to the public which initiated five ministries of Indonesia, namely: The Ministry of Research and Technology, Ministry of Communication and Information, Ministry of Justice and Human Rights, Ministry of National Education, and Ministry of State Apparatuses.

This program is aiming to save the budget and stimulate educational institutions to use open access in promoting open sources to access learning materials [27]. Recently, education in Indonesia emphasizes the global trending 21st century which is integrating all educational activities with the use of the internet. It is shown by the National Examination which was conducted through the computer-based test (CBT) in 2014. However, the equity of facilities distribution is becoming an obstacle for the government to conduct learning through the internet. Based on the survey data about Indonesian schools' condition, there are about 118.000 schools (out of 208.000 schools) have access to the internet in 2015; it means there are about 90.000 schools that don't have access to the internet [28]. Surprisingly, there are 17.000 schools still experience a lack of electricity especially in remote and border areas. To respond to this issue, The Indonesian ministry of education and the ministry of communication and information have collaborated to develop ICT services known as Universal Service Obligation (USO). This program was funded for several projects such as Palapa Ring project, 3GBTS in remote and border area, broadband access for education, agriculture, and health services. The massive development of national broadband networks shows the inclination trend of internet users in Indonesia. Based on the survey data conducted by the Indonesian internet association (APJII) in 2018 shows about 171 million population (out of 264 million) are connected to the internet. This user number has increased by about 10 percent since 2017, which internet user is only 54.86

3.2.1 Data Collection and Analyze

The validated questionnaire is converted into an online questionnaire using Google-form and distributed through 670 emails and 150 social media accounts to English lecturers who teach English in a higher education institution in Indonesia. The return rates were 330 respondents, but have been sorted to 280 respondents. The other 50 respondents do not fulfill the characteristic of targeted respondents who must be English lecturers teaching at the university level. The survey was done for a month during December 2018. The data collected then analyzed using chi-square to find the correlation between each aspect. Kinds of training experiences, ICT activities and problems of ICT implementation were described statistically. The Scale The questionnaire was adapted from(Muslem, Yusuf, & Juliana, 2018; Son, Robb, & Charismiadji, 2011), consisting of 35 items and five scales of measurements. There are five scales of measurement for the variable of knowledge and ICT literacy skill; Strongly agree, agree, neutral, disagree, and strongly disagree. For the variable of Internet and ICT activities frequency, there are also five scales of measurement; always, often, sometimes, rarely, and never. The instrument is validated by some experts before

applying it to collect the data and also undergone validity measurement using SPSS with the result of r greater than 0.113 and reliability measurement using Cronbach alpha with the result r greater than 0.7.

3.2.2 Development

most developed and developing countries have been investing to ICT integration in education because of the potentials of ICT for education. Computers and Internet technologies can be excellent instructional tools that transform education for the 21st century (David, 1991; Solomon & Schrum, 2007). Interestingly, ICT integration in developing countries may help them become "leapfrog nations" to successfully compete in the age of knowledge, research, innovation, and human development due to the capacity of ICT education to massively provide access of high quality learning materials and to connect people regardless the locations (Moravec, 2008). International organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) and The Organization for Economic Co-operation and Development (OECD) have been emphasizing the importance of ICT integration in education. UNESCO notes the importance of responding to change in education by integrating ICT in teacher education institutions such as teaching pre-service as well as in-service teachers to integrate ICT in teaching effectively through initiatives in several countries (UNESCO, 2002). Furthermore, OECD (2006) recommends that developing countries need to bridge the digital divide by providing adequate ICT resources to education and training teachers to integrate ICT in teaching. ICT integration in education can enhance education quality which will lead nations to be more competitive in this globalized world. Various policies and initiatives have been implemented to promote the use of ICT in education across the region. It is important to note that policies and initiatives vary across different regions within Southeast Asian countries. Additionally, the level of implementation and success may vary, influenced by factors such as funding, infrastructure availability, and teacher training. ICT has a significant impact on social and economic developments globally. In many nations, investments in educational reform and educational ICT are frequently justified by the need for economic and social progress. The aforesaid five SEAMEO member countries and its sector players view this ICT in education strategy as the pinnacle of the ultimate objective of changing the educational system. It is meant to serve as a guideline for utilising ICTs effectively and strategically to support the objectives and activities of the education sector as a whole as well as within the framework of national development initiatives. Therefore, the policy documents aim to provide both the broad framework for how it will be implemented, as well as policy directives for what needs to be done.

3.2.3 Implementation

Implementation of ICT in Education is an urgent thing and an accurate strategy in this era. Nevertheless, nowadays Indonesia still is one of the countries that has less development of ICT in education. Indonesia is a country of a thousand islands which are separated by an ocean which is the main obstacle to ICT infrastructure development in areas outside the main island (Java Island). Gaps in human resources and lack of teacher competency have also become an essential matter when implementing ICT in Education. On the other hand, Hong Kong and Singapore, as developed countries, already have useful infrastructure technology, and the human resources are qualified, so the implementation of ICT in Education is much more advanced compared to Indonesia.

The Indonesian government's policy of trying to implement information and communication technology, which began in 1969, has led to the formation of the Government Automation Cooperation Organization. Twenty years later, Indonesian Government concerning the Development Team and Utilization of the National Management Information System. In line with the next ten years, it was issued by Presidential Decree No. 186 of 1998 on the formation of the Indonesian Telemetry Coordination Team. Two years later the Presidential Decree has issued again on the same matter, number 50 of 2000 and also issued the same Presidential Decree number 9 of 2003. It was only in 2006 that Presidential Decree number 20 came out on the National Communication Information Technology Council. In its journey various strategies were developed in which there was recorded "Simnas" (National Management Information System) in the 1980s, Nusantara-21 in 1997, 1998 National Information Technology Framework, IIDP (Indonesia Infrastructure Development Program) in 1998, "Sifonas" (Information System National) in 2002, and e-Indonesia in 2006. Its implementation in the field of education is reflected starting from UUSPN article 35, paragraph 1 which states that "the standards of educational facilities and infrastructure include the classroom ..., other learning resources needed to support the learning process including the use of ICTs". A comprehensive strategy has been designed and outlined in the framework as follows(Mirfani, 2019):

3.2.4 Evaluation

Evaluation of the use of technology in online learning due to COVID-19, schools in the yellow zone are allowed to apply blended learning. However, PAUD is implemented 2 months after implementation in SD, SMP, SMA is carried out. This is because the implementation of health protocols for early childhood is quite complicated. In the process of implementing this online learning policy, other obstacles were encountered that came from human resources.

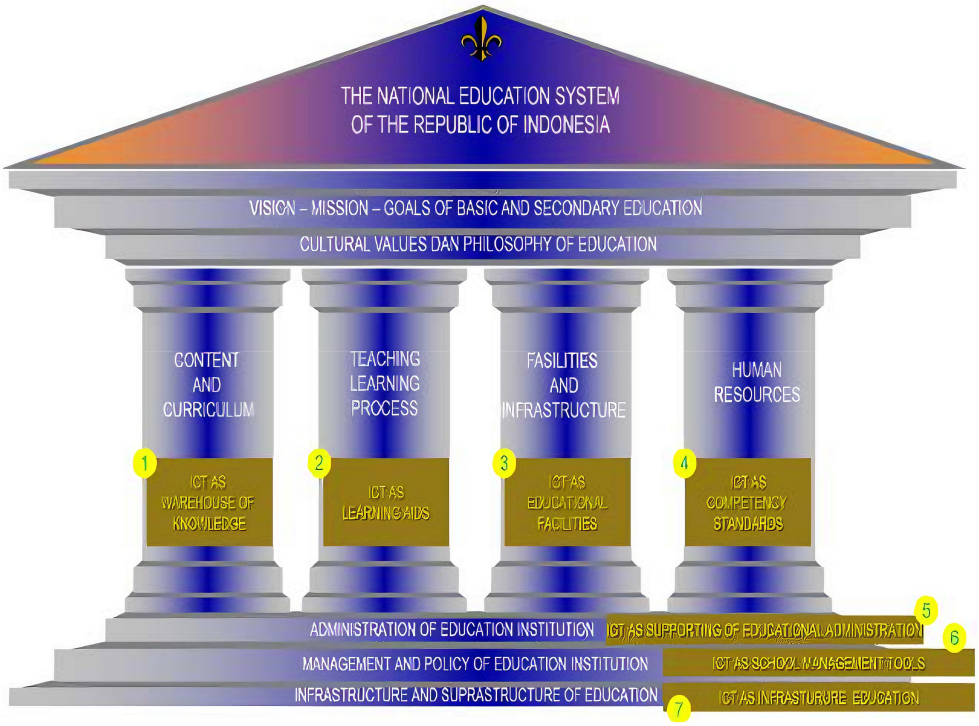

Figure 3.1: Application ICT in Education

This obstacle is the psychological factor of teachers and children that have an impact on parents. From the start, the teacher had to think hard about the lessons that would be carried out when the pandemic began. With discussions carried out together, a decision was made to provide learning with worksheets that were taken by the parents at any given time. As time goes by, teachers are required to provide interesting learning but not difficult for children. For schools that are accustomed to doing activities with worksheets, it will be a little relieved because all the teacher needs to do is make worksheets and then distribute them to students. However, for schools that rarely use worksheets, such as schools with the Montessori method or schools with the Sentry model, teachers must think hard about the activities that will be given to students. For schools that are balanced in providing activities in the form of worksheets and with existing tools in the classroom, learning becomes more interesting and varied. Teachers are accustomed to making worksheets and compiling lessons using existing tools in class and at school. In the meantime, children begin to find boredom in studying at home. Lack of interaction with children of his age coupled with assignments from school that easily bore children affects the child's psychology. Children become discouraged, easily moody, and tend to get emotional easily. Parents who usually give responsibility to the school eventually inevitably become teachers at home. Lack of knowledge and experience

in handling children's learning makes psychological changes to parents as well. Parents easily give up when teaching children to learn which results in protests against schools. In responding to the demands of parents, schools are unable to optimally solve problems. Using zoom meetings at first can solve the problem, but a new problem arises again because children turn out to get bored easily when attending online schools. Another policy taken by the school is a plan to hold a home visit or limited learning at school with attention to environmental health and cleanliness. However, the policy of the school supervisor does not permit schools to start learning at school. The teacher again has to think hard about this problem. The school superintendent insisted on prohibiting schools from starting learning again but did not provide a solution to the problem. Teachers as practitioners who directly meet the educational problems directly seem helpless. Based on the evaluation of learning, it was felt necessary to open learning directly, but on the other hand, regional education policymakers insisted not to open schools. This problem continues until now and has not yet found a clear point.

3.3 Place and Time of Research

This research was conducted in two schools in Indonesia: SMA IT Quaran Qordhova and Jannatun Naim International College and Boarding School. The data collection and analysis phases took place during the academic year of 2023, aligning with the school schedule to ensure relevant and accurate findings.

1. SMA IT Quaran Qordhova: This school was selected for its integration of ICT in the teaching and learning process, emphasizing modern educational practices and the use of digital tools.
2. Jannatun Naim International College and Boarding School: Known for its diverse student body and advanced technological infrastructure, this school provided an ideal environment to explore the impacts of ICT on educational outcomes.

The research spanned a period of six months, from March 2023 to August 2023, allowing for comprehensive data collection through surveys, interviews, and observations.

3.4 Product Development and Testing Step

Props or media are essential in learning because they are beneficial teachers and also Shiva. With the media, the learning process can be more productive, active, and even creative. Several presses can be held by the teachers in the management of the failure, which are

electronic or non-electronic media. Electronic media is technological development, gaining a place and attention is big enough for teachers and students as well as a significant influence on education development. So, electronic media is a conducive medium for teachers and students in the technological era. Related research discusses information and communication technology (ICT) on the implementation of ICT-based learning. ICT learning is used to innovate in creating media studies that can help students understand, create innovations, and creativity in the fields of science, technology, and the arts. In improving the competency of Islamic education, students can go through several stages of ICT-based learning and the improvement of core competencies. ICT Learning Media can help in the learning process effectively. The learning process is the process of communication that must be realized through the activities of sending and exchanging messages or information by each lecturer and students. A letter or data can be in the form of knowledge, skills, ideas, experiences, and so on. Through the communication process, messages or data can be absorbed and compromised by others. Related research shows that the use of ICT in education is felt more positive among students who use technology every day. Teachers, as the learning process executor, must be able to design, use, and evaluate ICT learning media. The use of technology in the learning activities in the classroom has some advantages, as learners work faster and more comfortable and enjoyable because of the interaction between learners with images, voices, colors, videos, and something International Journal of Information System & Technology instant. Technology is capable of generating positive emotions in the learning process. So, a teacher should be creative in using magnetic, electronic media to help students learn. ICT-Based Learning Media is a tool used in the learning process. By utilizing information technology or ICT (Information And Communication Technology).The development of ICT includes developing an educational system, both from a basic and higher levels of education. Various ways and media have been introduced and used in the learning process. Teaching with the aim that more and more lecturers are giving creativity in teaching and can produce more meaningful learning will undoubtedly improve the quality of education. Hybrid learning mechanisms are essential to improving the quality of learning media.

3.4.1 Preliminary Study and Information Gathering

The integration of information and communication technology (ICT) in education is increasingly seen as a crucial step towards enhancing educational outcomes. This section presents a preliminary study conducted at JaNIC High School in Lampung, Indonesia, focusing on the implementation of Learning Management Systems (LMS), Management Information Sys-

tems (MIS), and Journal Management Systems. This study evaluates the impact of ICT on teachers and students, aligning with the broader objectives set forth by the Indonesian Ministry of Education.

Background of ICT in Education in Indonesia

The Indonesian government has made significant efforts to integrate ICT into its education system. Initiatives such as the creation of the National Talent Management Agency and the "Freedom to Learn" reforms aim to enhance student achievement and modernize education by reducing administrative burdens on teachers and encouraging student-centered learning.

Preparedness and Challenges at JaNIC High School

The preliminary study assessed the readiness and identified challenges related to the implementation of ICT solutions at JaNIC High School. 1. Preparation of Participants:

a) Training sessions were conducted to familiarize teachers and students with the use of LMS, MIS, and Journal Management Systems.

b) A survey revealed a high level of readiness among participants, with a generally positive attitude towards the potential benefits of ICT in enhancing the educational experience.

2. Identified Challenges:

a) Infrastructure: The school's internet connectivity requires significant improvements to support the effective use of ICT systems.

b) Technical Skills: Both teachers and students need ongoing training to develop essential technical competencies.

c) Resource Allocation: Ensuring the availability of adequate digital equipment and educational materials is crucial for successful ICT integration.

Detailed Analysis of ICT Systems

1. Learning Management System (LMS):

a) Objective: Facilitate online learning, course management, and interaction between students and teachers.

b) Features include online course content, assignment submission, assessment tools, and communication channels.

c) Benefits: Provides greater flexibility in learning, easy access to educational resources, and increases student engagement.

2. Management Information System (MIS):

a) Objective: Simplify administrative and data management processes.

b) Features include student record management, attendance tracking, scheduling, and reporting.

c) Benefits: Enhances efficiency in school management, ensures accurate data management, and supports decision-making.

3. Journal Management System:

a) Objective: Manage the submission, review, and publication of academic journals.

b) Features include a submission portal, peer review management, editorial workflows, and publication tracking.

c) Benefits: Promotes academic research, ensures transparency in the publication process, and raises the academic standards of the institution.

Recommendations

Based on the findings from this study, the following recommendations are proposed to ensure successful ICT implementation at JaNIC:

a) Strengthen infrastructure by investing in robust internet connections and providing adequate technical support.

b) Enhance professional development through regular training programs for teachers and students to build ICT competencies.

c) Ensure the provision of essential digital tools and resources for all users to support effective integration.

3.4.2 Planing Stage

The planning phase of this research was crucial in establishing a strong foundation for understanding the complex dynamics of information and communication technology (ICT) integration in Indonesian educational institutions. This stage was structured methodically to address the research objectives, develop a comprehensive methodology and ensure the accuracy and reliability of the collected data. This process included setting precise research objectives, selecting an appropriate and representative sample, identifying robust data collection methods, preparing analytical tools, considering ethical concerns, and establishing a detailed timeline and resource management plan.

1. Definition of research objectives

The core of this research is the objectives that aim to describe the multifaceted impact of information and communication technology on teaching and learning processes in the

Indonesian Ministry of Education. The main goal is to investigate the impact of information and communication technology on educational outcomes, especially in terms of teaching effectiveness, student participation, and overall academic performance.

The research questions that guide this study are: What are the perceived benefits of ICT integration among teachers and students in Indonesia? How does the use of information and communication technology affect teaching practices and teachers' effectiveness in delivering curriculum content? To what extent does information and communication technology facilitate or hinder student engagement and learning outcomes in the Indonesian educational context? What challenges do teachers and students face in accepting and effectively using ICT tools in classrooms? How do regional differences and different levels of ICT infrastructure affect the overall impact of ICT on education?

These aims and questions were refined through an extensive review of the existing literature and preliminary discussions with educational stakeholders, ensuring that the research provided valuable insights in academic and practical domains.

2. Selection of the study sample

Given Indonesia's diverse educational landscape, selecting a representative study sample was a critical step in the planning process. The sample was carefully selected to reflect different levels of ICT adoption in different regions and types of schools, including urban and rural settings, as well as public and private institutions.

Selection criteria include: Geographical diversity: Schools from different provinces were included to account for regional differences in ICT infrastructure and access. Levels of ICT Adoption: Schools with different degrees of ICT integration were selected to enable a comparative analysis of its impact. Participant Roles: This study targeted teachers and students to gain a comprehensive view of the effects of ICT on the educational process. Experience with ICT: Participants were selected based on their familiarity and experience with ICT tools, ensuring a mix of novice and experienced users.

A stratified sampling method was used to ensure that the study sample was both diverse and representative of the wider population of schools under the Ministry of Education. This approach also facilitated the generalization of the study findings to the wider educational context in Indonesia.

3. Data collection methods

This research used a mixed-methods approach that combined both quantitative and qualitative data collection methods to provide a comprehensive understanding of the impact of ICT. This approach was chosen to capture the measurable outcomes of ICT use and the subjective and nuanced experiences of the participants.

Surveys and Questionnaires: A large-scale survey was designed and distributed to collect

quantitative data from a broad set of participants. The survey included Likert-scale questions, multiple-choice questions, and open-ended questions to measure the perceived impact of ICT on teaching and learning processes, as well as to identify common challenges and barriers to effective ICT integration. Interviews: Semi-structured interviews were conducted with a targeted sample of teachers, students and school administrators. These interviews provided in-depth insight into participants' experiences, attitudes, and opinions regarding the use of ICT. Interviews were recorded, transcribed and analyzed using thematic analysis to uncover key themes and patterns. Classroom observations: Direct observations were made in selected classrooms to evaluate the real-time use of ICT tools in teaching and learning activities. This method allows the researcher to assess the practical challenges and benefits of using ICT as well as to observe student-teacher interactions and levels of interaction.

4. Preparation of data analysis tools and protocols

To ensure the accuracy and validity of the research findings, a comprehensive data analysis plan was developed. This included selecting appropriate analytical tools and establishing protocols for data management and interpretation.

Quantitative analysis: The data from the survey and questionnaire were analyzed using statistical software such as SPSS and SmartPLS. Descriptive statistics were used to summarize the data, and inferential statistics, including regression analysis and ANOVA, were used to examine the relationships between variables and test research hypotheses. Qualitative analysis: The interview text and observation notes were thematically analyzed using NVivo software. This process includes coding the data, identifying emerging themes, and interpreting the findings in the context of existing literature and theoretical frameworks. Triangulation: To increase the validity and reliability of research findings, data triangulation was employed by comparing the results of different data sources (eg, surveys, interviews, and observations) to identify converging patterns and discrepancies.

5. Ethical considerations

Ethical considerations were critical throughout the planning phase to ensure that the research was conducted in accordance with the highest standards of academic integrity and respect for participants' rights.

Informed consent: Participants were given detailed information about the study's objectives, procedures, and potential risks before they agreed. Written informed consent was obtained from all participants, and parental consent was secured for students under 18 years of age. Confidentiality and Anonymity: All data collected is treated with complete confidentiality. To protect participants' anonymity, personal identifiers were removed during data analysis. Data were securely stored in password-protected files accessible only to the researcher and authorized personnel. Voluntary participation: Participants were informed

of their right to withdraw from the study at any stage without any consequences. This was particularly important in ensuring that participants felt comfortable and free to express their true opinions and experiences.

6. Time table and allocation of resources

A detailed project timeline was created to guide the research process from initiation to completion. This timeline included key milestones such as completion of the literature review, stages of data collection, data analysis, and final writing and submission of the thesis.

Project timeline: The timeline was divided into several phases, each with specific deadlines and deliverables. Regular progress reviews were scheduled to ensure that the investigation remained on track and that any potential delays were promptly addressed. Resource Management: Adequate resources including financial support, technological tools and human resources were allocated to facilitate smooth implementation. Funding was provided to cover the costs of travel, data collection tools, and software licenses. In addition, research assistants were employed to assist with data collection and analysis to ensure that the project could be completed within the allotted time frame.

This carefully planned phase laid the groundwork for a robust and comprehensive study, ensuring that the research was methodologically sound, ethically accountable, and strategically positioned to contribute meaningful insights into the field of educational technology in Indonesia.

3.4.3 Initial Product Development

Initial product development stage The cornerstone of the project aims to integrate ICT into the Indonesian education system. This step is critical to ensure that the developed ICT tool both meets the needs of teachers and students and is aligned with the overall goals of the Ministry of Education. The development process was structured around four key components: identifying needs, designing and prototyping, pilot testing, and overcoming challenges. Each of these components played a vital role in creating a tool that can effectively increase educational outcomes in various regions of Indonesia.

1. It needs to be identified and conceptualized The first step in the product development process was a comprehensive requirements analysis. This analysis was very important to understand the educational challenges in Indonesia, especially the differences between urban and rural schools. Many rural schools face significant constraints such as insufficient access to educational resources, limited technological infrastructure, and varying levels of teacher readiness to integrate information and communication technology into their teaching prac-

tices. The analysis revealed a clear demand for a tool that can address these challenges by providing features such as interactive content, offline access, and mechanisms for real-time feedback. These features are designed to bridge the education gap and provide access to quality education for all students, regardless of location.

The conceptual design of the ICT tool was strongly influenced by this analysis. The development team made it a priority to create a tool that was not only technologically advanced, but also adaptable to different teaching styles and learning environments. The design process involved consultation with instructors and students to ensure that the tool meets their needs and enhances their learning experiences.The conceptualization phase also incorporates insights from various educational theories, particularly those that emphasize active learning and student engagement. By integrating elements of learning theories, this tool is designed to promote collaboration and interaction, key factors in improving student performance and engagement.

2. Design and prototyping After the needs identification stage, the project was moved to the design and prototyping stage. This phase was guided by design thinking principles that emphasize empathy, edition, and iterative testing. The prototype was developed with a focus on usability, ensuring that the tool can be easily navigated by users with varying levels of digital literacy. One of the primary goals at this stage was to create a tool that could operate efficiently in low-resource settings. The development team paid special attention to optimizing the tool for low-bandwidth environments, ensuring that it can be used even in areas with limited internet connectivity. This was critical to making the tool accessible to students and teachers in remote areas, thereby supporting the Ministry of Education's goal of equitable access to quality education. The design process was highly iterative and included several rounds of prototyping and testing. Each iteration was tested in controlled environments, allowing the development team to refine the tool based on user feedback. This approach ensured that the final product was not only technically strong, but also matched the needs and expectations of users.

3. Pilot testing and feedback The testing phase was a critical step in validating the tool's effectiveness in real-world educational settings. This phase involved the deployment of the prototype in a series of schools in different regions of Indonesia, including urban and rural areas. During the test, teachers and students used the tool in their daily educational activities and provided valuable feedback on its use and effectiveness. The feedback gathered during this phase was instrumental in refining the tool and ensuring that it met the diverse needs of its users. The iterative feedback loop allows the development team to make continuous improvements, making it a tool well suited to the Indonesian educational context. The testing phase also emphasized the importance of providing adequate support for users. In

response, the development team developed a comprehensive set of support materials, including training videos, user manuals, and a help desk service. These resources are designed to help educators and students use the tool effectively to ensure it can be seamlessly integrated into their teaching and learning practices (UNESCO, 2024).

4. Challenges and mitigation strategies The development of ICT tools was not without challenges. One of the main challenges was to ensure that the tool could be effectively integrated into the existing educational infrastructure. Many schools in Indonesia, especially in rural areas, lack the technological resources needed to fully utilize ICT tools. To solve this problem, the development team focused on creating a tool that is adaptable and can work in different settings. Another important challenge was the different levels of digital literacy among teachers and students. To overcome this problem, the development team implemented a comprehensive training program that included hands-on workshops, online tutorials, and ongoing technical support. The program is designed to build users' confidence in using the tool and help them integrate it into their daily activities.

Finally, ensuring the stability of the tool was a key consideration during the development process. The tool is built on an open source platform that allows for easy customization and adaptation as training needs evolve. This approach not only reduced development costs, but also ensured that the tool could be maintained and updated over time, making it a viable solution for the long term.

3.4.4 Expert Validation

The integration of ICT in education by the Indonesian Ministry of Education signifies a major shift in teaching practices. An expert validation process was conducted to ensure the study's findings aligned with current educational standards and verified the effectiveness of ICT implementation.

1. Selection of Experts: Experts with extensive knowledge in Educational Technology and ICT from Lampung University were involved:
   (a) Dr. Rangga Firdaus, S.Kom, M.Kom – Head of the Department of Educational Technology, specializing in the integration of ICT in education.
   (b) Dr. Riswandi, M.Pd – First thesis advisor and expert in Educational Technology, with extensive experience in ICT consultancy within educational settings.
   (c) Dr. Muhammad Nurwahidin, M.Si – Second thesis advisor, renowned for research and policy analysis in the realm of educational ICT.
2. Validation Process:

(a) Review of Research Framework: Experts assessed the research goals, hypotheses, and methodologies for alignment with ICT integration challenges in Indonesia.

(b) Evaluation of Data Collection Tools: Experts reviewed and refined surveys and interview guides for clarity and reliability.

(c) Preliminary Findings Analysis: Initial findings were presented for feedback, which led to more sophisticated statistical analyses.

3. Results and Recommendations:

(a) Enhanced data collection tools and comprehensive data gathering.

(b) Refined analysis techniques for deeper insight into ICT's impact on education.

(c) Actionable policy recommendations shaped to improve ICT integration in schools.

The expert validation confirmed the study's relevance and methodological rigor, providing a strong basis for future policy development in ICT-enhanced education.

3.4.5 Initial Product Revisions

After a comprehensive expert validation process, several critical revisions were implemented to refine the ICT integration model to ensure that it is both effective and relevant in Indonesia's diverse educational context. These revisions resulted from the need to address the challenges and gaps identified by the expert panel, which included eminent academics and professionals with extensive experience in information and communication technology in education. Revisions targeted key aspects of the study, including survey instruments, data analysis techniques, policy recommendations, ICT integration framework, experimental experimental settings, and integration of emerging technological innovations. These developments were essential in aligning the study with current educational standards and ensuring that the ICT integration model can be effectively implemented in different types of schools in Indonesia.

1. Refinement of survey tools

The expert panel identified several areas where survey instruments could be improved to increase the clarity, relevance, and effectiveness of the data collection process. Originally, the survey questions were somewhat generic, which could have led to vague responses that may not accurately reflect the nuances of ICT integration in different educational settings. To address this, the questions were reworded to be more specific and targeted to ensure that respondents could easily get more accurate answers. In addition, new questions were asked to explore previously overlooked aspects of ICT use, such as specific barriers teachers face when

integrating technology into their classrooms, the level of support they receive from school administration, and their attitudes toward professional development. were continuously introduced in information and communication technology. Refined survey instruments are designed to collect a wider range of data, which allows for a deeper analysis of factors influencing ICT adoption and its impact on teaching and learning outcomes (Halim, 2023).

2. Strengthen data analysis techniques

The initial approach to data analysis was relatively simple, relying mainly on descriptive statistics and basic regression models. While these methods provided useful insights, they were insufficient to fully demonstrate the complex relationships between ICT use and educational outcomes. In response to expert feedback, the data analysis plan was revised to incorporate more advanced statistical techniques. For example, structural equation modeling (SEM) was introduced to analyze the relationships between multiple variables simultaneously, allowing for a more detailed understanding of how ICT integration affects different aspects of teaching and learning. to be This method was particularly valuable in identifying indirect effects, such as how teachers' use of ICT may affect student engagement, which in turn affects academic performance. In addition, the use of multivariate analysis enabled this study to consider diverse conditions in different schools and provide a more accurate and comprehensive picture of the impact of information and communication technology in education (Sari, 2022).

3. Strengthen policy recommendations

The policy recommendations that emerged from this study were critically evaluated and revised to ensure that they were practical, practical, and specifically tailored to the needs of the Indonesian education system. Experts emphasized the importance of developing recommendations that can be realistically implemented within the existing infrastructure and resource constraints of Indonesian schools. As a result, the recommendations were expanded to include a phased implementation strategy that allows for the gradual adoption of ICT, beginning with pilot programs in a group of schools. This phased approach is designed to give the Ministry of Education an opportunity to assess the effectiveness of ICT integration on a smaller scale before committing to a nationwide rollout. In addition, the revised recommendations include strategies for building the capacity of teachers and school administrators through continuous professional development programs. These programs are designed to equip educators with the skills and knowledge needed to effectively integrate ICT into educational practices and adapt to the rapidly changing technological landscape (Andriani, 2021).

4. Redesigning the ICT integration framework

The ICT integration framework itself underwent a significant redesign to be more user-

friendly, flexible and adaptable to the diverse educational environments found throughout Indonesia. The initial framework was somewhat rigid, making it difficult to effectively implement schools with different levels of ICT infrastructure and resources. In response to expert feedback, the framework was revised to include multiple implementation pathways, allowing schools to choose the approach that best fits their specific context. For example, corporate schools with limited ICT infrastructure can start with basic digital literacy programs, focusing on equipping teachers and students with basic skills such as using word processors and navigating the Internet. On the other hand, schools with more advanced resources can implement more sophisticated technologies such as interactive whiteboards and learning management systems that allow for a more interactive and engaging learning experience. In addition, ChaThe revised framework includes detailed guidelines for monitoring and continually evaluating ICT integration, enabling schools to assess the effectiveness of their ICT initiatives and make necessary adjustments over time. This process of continuous improvement is necessary to ensure that ICT remains a valuable tool to enhance teaching and learning rather than becoming an additional burden for educators (Nugroho, 2023).

5. Pilot test settings

The pilot test phase was also significantly expanded and revised to ensure that it provides robust and reliable insight into the feasibility and effectiveness of the ICT integration model. Initially, the experiment was limited to a small number of urban schools that did not adequately represent the diversity of educational environments in Indonesia. Based on expert recommendations, the pilot was expanded to include a wider range of schools, including schools in rural and remote areas, as well as schools with different levels of ICT readiness. This expansion was crucial for understanding the unique challenges and opportunities associated with integrating ICT in different contexts. In addition, the pilot phase now includes a more comprehensive evaluation component that includes both quantitative and qualitative criteria. Quantitative data, such as test scores and attendance, are used to measure the direct impact of ICT on student performance, while qualitative data, such as teacher and student feedback, provide insights into the user experience and perceived value of ICT tools. These multiple lines of evidence ensure that pilot test results are both reliable and applicable, providing a solid foundation for final product release (Widodo, 2022).

6. Integration of technological innovations

To ensure that the ICT integration model remains relevant and effective, experts recommended incorporating the latest technological innovations into the framework. These innovations include cloud-based platforms that facilitate real-time collaboration and resource sharing between teachers, students, and administrators, and mobile learning applications, which provide flexible access to educational content and enable personalized learning experi-

ences. . The integration of these technologies was aimed at enhancing the learning experience by making it more interactive, engaging and accessible. For example, cloud-based tools like Google Classroom and Microsoft Teams allow teachers to create and distribute assignments, provide feedback, and facilitate discussions, all on a single platform. Meanwhile, mobile learning apps like Khan Academy and Duolingo give students the opportunity to learn at their own pace and in their own time, making education more flexible and tailored to individual learning needs. Incorporating these technologies also required the development of new guidelines for their selection, implementation and maintenance, ensuring that schools can effectively integrate these tools into their existing systems and maximize their benefits for teaching and learning (Arifin, 2023).

The revisions mentioned above were necessary to ensure that the ICT integration model is not only theoretically sound, but also practically viable and compatible with the diverse educational contexts that exist in Indonesia. The iterative process of expert validation and subsequent revisions significantly strengthened the model, establishing it as a robust and scallable tool for improving educational outcomes through the strategic use of ICT. By addressing specific challenges identified by experts, the revised model will be better equipped to meet the needs of Indonesian schools and provide them with the tools and strategies they need to effectively integrate ICT into teaching and learning processes. These improvements also ensure that the model remains relevant in the face of rapidly changing technological advances, making it an invaluable resource for educators and policy makers.

3.4.6 Limited Product Trial

Limited product testing was a strategic step to evaluate the practical applicability of the integration model The revised ICT was implemented in a diverse range of educational settings in Indonesia. This trial was necessary to gather empirical evidence on the effectiveness of ICT tools and strategies, understand challenges in different school contexts, and refine the model based on real-world feedback before wider implementation. The experimental insights were invaluable in shaping the final version of the ICT integration model.

School selection and preparation

The process of selecting schools for the limited product trial was carefully designed to ensure that the trial could provide a comprehensive understanding of the impact of the ICT integration model. The selection included 20 schools representing a wide range of settings from urban to rural and schools with different levels of ICT infrastructure in place. This variation was very important in testing the compatibility of the model in different contexts. The selected schools were not only geographically diverse, but also varied in socio-economic

profiles, ensuring that the results of the trial were relevant to a wide range of educational settings in Indonesia (Suryanto, 2023).

Before starting the trial, considerable preparatory work was done to ensure that the selected schools were ready to implement ICT tools. This includes upgrading ICT infrastructure where necessary, providing schools with the necessary equipment, and training teachers who use these tools. The preparation phase also included setting up a support system to provide technical assistance during the trial period, minimizing disruptions and ensuring that any issues could be addressed quickly. These preliminary steps were crucial to ensure that the trial ran smoothly and that the data collected were reliable and valid.

Implementation and monitoring

The ICT integration model was implemented over a six-month period, during which the selected schools used various ICT tools as part of their regular teaching and learning activities. These tools included interactive whiteboards, digital content delivery systems, learning management systems, and mobile learning apps. The implementation phase was closely monitored by the research team who conducted regular site visits and engaged with teachers, students and administrators to gather ongoing feedback.

One of the unique aspects of this experiment was the active participation of teachers in the implementation process. Teachers were not only trained to use ICT tools, but also encouraged to experiment with different ways of integrating these tools into their teaching practices. This approach allowed the research team to see how the tools were being used in diverse and innovative ways, providing deeper insight into their potential and limitations. The active participation of teachers also led to greater ownership of the process, which was reflected in the overall positive attitude towards ICT integration observed during the experiment (Putra, 2022).

Data collection and analysis

A rigorous data collection process was implemented to collect quantitative and qualitative data throughout the trial. Quantitative data included measures such as student performance in standardized tests, attendance and ICT tool usage statistics. These data points provide measurable indicators of the impact of ICT integration on student outcomes.

In addition to quantitative data, a significant amount of qualitative data was collected through interviews, focus group discussions, and observational studies. These qualitative methods were critical in understanding the experiences of the teachers and students involved in the trial, revealing insights that could not be obtained through quantitative measurements alone. For example, qualitative data highlighted the ways in which students' engagement with learning materials increased when interactive technologies were used, as well as the challenges teachers faced in adapting to new teaching methods (Hidayat, 2022).

The analysis of the collected data was done using a mixed method. Statistical techniques were used to identify trends and evaluate the effectiveness of ICT tools for quantitative data. Meanwhile, thematic analysis was used to process the qualitative data, allowing the research team to identify recurring themes and patterns in the participants' experiences. Combining these two approaches provides a comprehensive understanding of the impact of ICT integration, providing both broad trends and deep insight into specific issues.

Key findings and challenges

The findings of this trial highlighted several key benefits of ICT integration as well as important challenges that needed to be addressed. One of the most significant results was the positive effect on student participation. The interactive and multimedia elements of ICT tools made the lessons more interesting, which led to increased participation and attention of students. Teachers also reported that ICT tools facilitate differentiated instruction and allow them to tailor their teaching to the needs of individual students more effectively.

However, the trial revealed significant challenges, particularly in schools with limited resources. For example, in rural areas, lack of reliable Internet access was a major barrier to effective ICT integration. Teachers in these schools often struggled with communication problems that disrupted lessons and made it difficult to make full use of ICT tools. In addition, the trial highlighted the need for ongoing technical support and more comprehensive training for teachers. While the initial training provided was helpful, many teachers expressed the need for continuous professional development to keep pace with the evolving demands of ICT integration (Rahmawati, 2021).

Recommendations for modifying the model

Based on the findings of the trial, several recommendations were made to modify the ICT integration model. First and foremost, there was a clear need to improve infrastructure in under-resourced schools, especially in rural areas. This included investing in more secure internet connections and ensuring that schools have access to the necessary hardware and software.

Second, the trial emphasized the importance of continuing professional development for teachers. It was recommended that the ICT integration model include a structured program of continuing education, workshops, and peer coaching opportunities. This ensures that teachers are not only equipped to use ICT tools, but are also able to adapt to new technologies and integrate them effectively into their teaching practices.

Finally, the need for a flexible implementation strategy was emphasized. The ICT integration model should offer different levels of adoption, allowing schools to choose the approach that best suits their specific needs and capabilities. This flexibility enables schools with different resources to implement the model at a pace that is manageable for them,

ensuring a more sustainable and effective integration of ICT in diverse learning environments.

Summary and future directions

Limited product testing was a critical component in the development of the ICT integration model. This provided valuable insights into the benefits and challenges of ICT in education, which were used to refine the model and make it more applicable to various Indonesian school contexts. Recommendations from the trial will guide the final configuration of the model, ensuring that it is robust, flexible and capable of increasing educational outcomes across Indonesia.

3.4.7 Broad Implementation Field Test

After the limited product testing provided the necessary insights, the next logical step was to scale the ICT integration model to a wider range of schools in Indonesia. This phase, referred to as the field test of extended implementation, aimed to thoroughly evaluate the model in a wide variety of educational settings, with a focus on understanding its impact on a larger scale. Field testing was critical in evaluating the scalability, stability, and overall effectiveness of the model when deployed in diverse and challenging environments.

Objectives and scope of the field test The extensive implementation field test was designed with multiple goals in mind. The primary objective was to validate the ICT integration model under real-world conditions in various Indonesian schools, from well-resourced urban schools to under-resourced rural institutions. Unlike limited product testing, which was more controlled, field testing sought to expose the model to the complexities of full-scale deployment, identifying not only successes but also systemic issues that could arise during a large-scale implementation. Slow (Hartono, 2023).

Another important objective was to assess the long-term sustainability of ICT initiatives. This includes assessing whether the initial training and support provided is sufficient for continued success and whether schools can independently maintain and expand ICT use over time. By looking at these factors, the field test provides a more comprehensive understanding of what is needed for the model to be successful in the long term.

Choice of schools and preparation One of the key components of the field test was the selection of a representative sample of schools that could provide meaningful data in various contexts. The sample consisted of 50 schools that were selected through a stratified sampling method to ensure representation in different regions, socio-economic conditions and levels of existing ICT infrastructure. This varied selection was crucial to test the adaptability and effectiveness of the model in different settings, from technology-rich urban schools to remote rural schools with limited access to resources (Widjaja, 2023).

Before starting the field test, an extensive preparation phase was carried out. Each school underwent a thorough needs assessment to identify gaps in ICT infrastructure and teacher preparation. Then the schools were provided with necessary hardware and software upgrades along with targeted training programs for teachers, managers and technical staff. The preparation phase also includes setting up robust support mechanisms, such as help desks and on-site technical assistance, to handle any issues that may arise during implementation. This groundwork was vital in leveling the playing field and ensuring that all schools, regardless of their starting point, had the tools and support they needed to fully participate in the field trial. Implementation and support mechanisms

The field test implementation phase is designed to mimic the full-scale rollout of the ICT integration model. During a 12-month period, the selected schools were expected to integrate ICT tools into their daily operations with an emphasis on increasing student engagement, facilitating personalized learning and promoting collaborative teaching practices. Schools received ongoing support throughout this period, including regular visits from ICT specialists, access to an online troubleshooting platform, and continuing professional development opportunities for teachers.

The distinctive feature of this stage was the emphasis on teacher's independence and innovation. Teachers were encouraged to explore different ways of using ICT tools and adapt them to the specific needs of their classrooms. This approach not only fostered creativity and innovation, but also provided valuable insights into how ICT tools can be effectively used in various educational contexts. This flexibility allows schools to tailor implementation to their unique circumstances, thereby maximizing the potential benefits of ICT tools (Sukmawati, 2022).

Comprehensive data collection strategy Extensive implementation field testing uses a comprehensive data collection strategy to obtain a wide range of information about the effectiveness of the model. Quantitative data were collected through standardized tests, attendance records, and digital usage reports, which provided clear measures of student performance, engagement, and patterns of ICT use. These data were necessary to measure the direct effects of ICT integration on educational outcomes.

In addition to quantitative data, the field test emphasized qualitative data collection through interviews, focus groups, and observational studies. These methods are designed to capture the experiences, perceptions and challenges faced by teachers, students and administrators. Qualitative data provide a deeper understanding of how ICT tools are used in practice and highlight areas where further improvement is needed. For example, interviews with teachers revealed practical challenges they faced, such as the need for more flexible ICT tools that could easily adapt to different teaching styles (Prasetyo, 2022).

Data were analyzed using advanced statistical methods and thematic analysis. Statistical analysis allowed the research team to identify significant trends and correlations in the quantitative data, while thematic analysis of the qualitative data helped uncover underlying patterns and issues that would have been possible only through quantitative measures. not revealed This dual approach ensures a thorough assessment of the ICT integration model and provides a balanced view of its strengths and areas for improvement. Main findings from the field test

The field experiment revealed several important findings that were useful in further refining the ICT integration model. One of the most encouraging results was the positive impact on student performance, particularly in schools that had previously shown lower academic achievement. The data showed that students in these schools experienced significant improvements in their test scores, attendance, and overall participation, indicating that ICT tools were effective in creating a more interactive and motivating learning environment.

Teachers also reported significant changes in their teaching practices as a result of ICT integration. The ability to customize lessons and provide differentiated instruction was especially important, as it allowed teachers to more effectively address the diverse needs of their students. The collaborative features of ICT tools promote greater interaction among students, resulting in a more dynamic and participatory classroom environment.

However, the field test also identified ongoing challenges that need to be addressed. Schools in rural areas still faced significant barriers, such as unreliable Internet access and limited technical support. These issues often limited the full use of ICT tools and required more resources and strategies to overcome them. Furthermore, while initial teacher training was effective, there was a clear need for continuing professional development to keep pace with rapid advances in educational technology and to ensure that teachers were confident in using the tools effectively (Rahmawati, 2021).

Recommendations for full-scale implementation Based on the results of the extensive implementation field test, several key recommendations were made to guide the full-scale rollout of the ICT integration model throughout Indonesia. First, it was suggested that more investments be made in improving ICT infrastructure in low-resource areas. This requires not only increasing Internet connectivity, but also ensuring that schools have access to the latest hardware and software necessary for effective ICT integration.

Second, the importance of continuous support and professional development of teachers was emphasized. It is recommended that a comprehensive and ongoing professional development program be developed that includes both face-to-face and online training opportunities. The program ensures that teachers stay up-to-date with the latest technological developments and are equipped to effectively integrate new tools into their teaching prac-

tices.

Finally, the field test emphasized the need for a flexible and context-sensitive implementation strategy. The ICT integration model should provide for different levels of adoption and enable schools to choose the implementation path that best suits their context and specific needs. This flexibility helps to ensure that the model is not only scalable, but also sustainable in the long term, supporting schools as they gradually increase their capacity to integrate ICT.

Final thoughts The extensive implementation field test was a critical step in validating and refining the ICT integration model for full-scale adoption. The insights gained from this step provide a detailed understanding of the model's strengths and areas for improvement, ensuring that the final version of the model is robust, flexible, and capable of enhancing educational outcomes in a wide range of contexts. The field test recommendations play a pivotal role in guiding the next steps and ensuring that the ICT integration model can be successfully implemented across Indonesia's diverse educational landscape.

3.4.8 Product Revision/Improvement

The process of product review and improvement is a critical aspect of ensuring that information and communication technology (ICT) tools used in educational settings remain effective, relevant, and able to meet the evolving needs of teachers and students. In the context of the Indonesian Ministry of Education, where schools range from high-resourced urban institutions to low-resourced rural schools, the ability to adapt and improve ICT tools is essential for widespread and successful implementation.

Product reviews usually begin by systematically gathering feedback from the tools' primary users—teachers, students, and school administrators. This feedback is collected through various methods including surveys, interviews and direct observations. According to (Fu, 2013), this feedback loop is critical for identifying specific areas where improvement is needed, such as user interface issues, the need for additional features, or content that better aligns with local educational standards. Collected feedback helps developers understand how ICT tools perform in real-world situations and where they may fall short in meeting users' needs.

(Yidana and Buabeng-Andoh, 2015) emphasize that the revision process is not simply about fixing bugs or adding new features, but rather an iterative cycle of testing, feedback and refinement. This iterative process ensures that each revision of the product is more aligned with the needs of its users, ultimately making the tools more effective in increasing learning outcomes. For example, revisions may include optimizing the software to perform

better in environments with limited Internet bandwidth, a common challenge in many rural areas of Indonesia.

After identifying the necessary fixes, the developers start iterative updates for the ICT products. These updates will not be released immediately, but will first be tested in controlled test environments. This step is critical because it allows educators to assess whether revisions adequately address identified issues without introducing new issues. Successful pilot tests are then followed by wider implementation, during which the revised products are deployed in a larger number of schools. This gradual scaling process helps to ensure that ICT tools remain robust and effective, even when used in diverse learning environments (Pardede, 2019).

In addition, ongoing support and professional development are essential to the success of product revisions. As pointed out by (Pihir et al., 2019), teachers should be adequately trained on the new features and functions introduced during the revision process. Without proper training, even the best ICT tools may fail to achieve the desired effect because users are not fully aware of how to use them effectively. The professional development programs that accompany the revised product launches ensure that educators can confidently integrate these tools into their teaching practices, ultimately leading to better learning outcomes for students.

In addition to training, ongoing support mechanisms such as help desks, online resources, and peer support networks are essential to assist educators as they navigate new or updated tools. This support is especially important in the early stages of implementation, where teachers may encounter unexpected challenges or need additional guidance. By providing ongoing support, educational institutions can ensure that ICT tools are used to their full potential, thereby maximizing their impact on student learning.

The ultimate goal of product review and improvement is to create ICT tools that are not only technologically advanced, but also educationally appropriate and user-friendly. This is in line with the broader aim of the Ministry of Education in Indonesia to use technology to improve the quality of education across the country. By systematically reviewing and improving ICT products, the Ministry can ensure that these tools remain effective in supporting the diverse needs of Indonesia's educational landscape, from urban centers to remote rural areas.

3.5 Research Subjects

The selection of research subjects is one of the important components of this study, because it directly affects the validity and generalised of the findings. To fully investigate the impact of

information and communication technology (ICT) on teaching and learning in the Indonesian Ministry of Education, a diverse and representative sample of teachers and students was carefully selected. This approach ensures that this research captures the diverse experiences and outcomes associated with ICT integration across Indonesia's multifaceted educational landscape.

Participating teachers Teachers play a key role in the successful adoption and integration of information and communication technology in educational environments. Therefore, it is important to select a representative sample of teachers to understand the broader implications of ICT use in classrooms. Participating teachers were selected from a wide range of educational institutions across Indonesia, including primary, middle and high schools. This taxonomy ensures that the study covers a wide range of educational practices and experiences.

The selected teachers differ significantly in their experience with ICT. This diversity is intentional, as it allows the study to examine how different levels of technology proficiency and comfort affect the implementation and effectiveness of ICT in teaching. (Ward and Parr, 2010) emphasize that teachers who are early adopters of technology often face different challenges compared to those who are less familiar with ICT tools. Early adopters may have difficulty integrating new tools into existing instructional frameworks, while less experienced teachers may find the learning curve associated with new technology more daunting. By including teachers with varying degrees of ICT experience, this study can provide a more nuanced understanding of these challenges and the support structures necessary to overcome them.

In addition to their ICT experience, teachers from schools with different levels of infrastructure were also included. This includes well-resourced urban schools with high-speed Internet access and modern digital devices, as well as rural schools where such resources may be scarce. The inclusion of teachers from these diverse settings is important, as it reflects the real-world differences in technology access that exist across Indonesia. (Buabeng-Andoh, 2012) emphasizes that infrastructural disparities can significantly affect the effectiveness of ICT in education and it is essential to understand how teachers adapt to these challenges. The study also considered the subject areas taught by the participating teachers. The impact of ICT can vary greatly depending on the subject, as different disciplines may require different types of technology or teaching approaches. For example, ICT tools used in science education may include simulations and virtual labs, while in language arts, digital storytelling and online collaborative writing platforms may be more common. By including teachers from different disciplines, this study can investigate how ICT supports or challenges the delivery of content in different subjects.

Participating students The students participating in this study were selected to supplement the teacher sample to ensure that this study could examine the interactions between teaching practices and student learning outcomes in the context of ICT integration. Students were selected from the same schools as the participating teachers to maintain consistency in the educational settings studied. This alignment allows for a comprehensive analysis of how ICT impacts teaching and learning in an organizational context.

The student sample was designed to be as diverse as possible, including students from different grade levels, socioeconomic backgrounds, and geographic locations. This diversity is necessary to understand how different factors affect students' interaction with ICT and its benefits. (Valtonen et al., 2011) show that age and grade level can significantly affect how students interact with technology, with younger students often requiring more guided instruction, while Older students may benefit from independent and self-directed learning opportunities.

Socioeconomic status (SES) is another critical factor considered in the selection of participating students. In Indonesia, as in many countries, SES can play an important role in determining access to technology and the Internet. Students from higher SES backgrounds may have greater access to digital devices at home, enabling them to engage more fully with ICT-based learning both inside and outside the classroom. In contrast, students from lower SES backgrounds may rely entirely on school-provided resources for their ICT experiences, which can limit their exposure to and interaction with these tools (Warschauer and Matuchniak, 2010). By including students from a range of socio-economic backgrounds, this study aims to explore the ways in which SES influences the effectiveness of ICT in education.

Geographical location is another important variable in this research. Indonesia's vast and diverse geography means that students in urban areas often have better access to ICT resources than students in rural or remote areas. This disparity can affect not only students' access to technology, but also the quality of their ICT experiences. Students in urban schools may have daily access to high-speed Internet and modern computer labs, while students in rural areas may only have intermittent access to older technology. By including students from urban and rural schools, this study can examine how these geographic disparities affect the effectiveness of ICT in enhancing student learning.

In addition, students' previous experience with information and communication technology was one of the key points in their selection. This aspect is important because students who have more experience using digital tools may engage with ICT in more complex ways than those who are new to such technologies. This study includes students who use ICT tools extensively as part of their education as well as those who have recently started interacting with these technologies. This scope allows the study to examine how prior experience affects

students' ability to adapt and benefit from ICT in their learning processes. Importance of research topics

The diverse selection of research topics in this study is designed to provide a comprehensive understanding of the impact of information and communication technology on education in Indonesia. By including a wide range of teachers and students from different backgrounds, this study ensures that its findings are relevant across the diverse educational settings found in the country. This approach not only enhances the credibility of the research, but also ensures that the results can be generalized to inform wider policy and action.

The inclusion of participants from different socioeconomic backgrounds, geographic locations, and levels of ICT experience allows the study to address critical issues related to educational equity. As (Fu, 2013) points out, addressing these disparities is essential to ensure that the benefits of ICT are accessible to all students, regardless of their background. The findings of this study contribute to a deeper understanding of how ICT can be used to bridge educational gaps and promote equity in learning outcomes across Indonesia.

In summary, the research subjects selected for this study provide a rich and diverse sample that represents the broader educational landscape in Indonesia. Their diverse experiences and backgrounds provide valuable insights into the challenges and opportunities associated with ICT integration and help inform strategies for the effective and equitable use of technology in education.

3.6 Data Collection Techniques

The data collection techniques used in this study were carefully selected to collect comprehensive and nuanced information about the impact of information and communication technology (ICT) on teaching and learning in the Indonesian Ministry of Education. A combination of quantitative and qualitative methods ensures that the data collected is both robust and reflective of the diverse educational environments across Indonesia. This multimethod approach allows for a comprehensive understanding of how ICT integration affects different aspects of education, from classroom practices to student learning outcomes.

Survey and questionnaire were the primary tools for collecting quantitative data in this research. These tools are designed to collect a wide range of information from teachers and students about their experiences with ICT. These surveys included structured questions covering key areas such as frequency of ICT use, types of technologies employed, perceived effectiveness, challenges ahead, and overall impact on teaching and learning processes. The design of the surveys was based on the existing literature in the field of information and communication technology in education, ensuring the relevance of the questions and consid-

ering the key objectives of the study (Buabeng-Andoh, 2012). Closed-ended questions were used to collect standardized data that were easily amenable to statistical analysis, while open-ended questions allowed respondents to provide more detailed descriptions of their experiences. This mixed-format approach enables the study to capture both broad trends and subtle individual differences.

In-depth interviews were conducted to supplement the quantitative data obtained through the survey. The interviews provided an opportunity to explore qualitative aspects of ICT integration that may not have been fully captured through surveys alone. By interacting directly with teachers, students, and school administrators, this study was able to gain deeper insight into personal experiences and perceptions surrounding the use of ICT in education. The interviews were semi-structured, meaning that while they followed a predetermined set of questions, there was flexibility to explore new topics during the conversation (Ward and Parr, 2010). This approach was particularly effective in uncovering the underlying reasons behind specific survey responses, such as why certain ICT tools were more popular than others, or why certain challenges were more salient in certain settings. Interview participants were selected from the broader survey sample, ensuring that interviews reflected the diversity of study participants. Classroom observations were another key method of qualitative data collection used in this study. Observations were conducted in a variety of educational settings, including urban, suburban, and rural schools, to capture the real-time use of ICT tools in diverse classroom environments. This method allowed the research team to directly observe how teachers and students interact with ICT and provide a practical perspective on the integration process. During the observations, special attention was paid to the way teachers use information and communication technology in the curriculum, the types of technologies used, and the level of students' engagement with these tools. Observers also noted any challenges that arose during the use of ICT, such as technical issues or difficulties in integrating technology with the curriculum. These observations provide concrete examples of how ICT is used in practice, which is essential to understand its real impact on teaching and learning (Valtonen et al., 2011). Classroom observations also allowed the study to identify best practices in ICT integration. For example, observers can learn which instructional strategies are most effective in increasing student engagement or how specific ICT tools are used to facilitate differentiated instruction. These data were crucial for developing recommendations on how to improve the integration of ICT in different educational settings.

Focus groups were conducted with teachers and students to facilitate discussion about their experiences with ICT. Unlike individual interviews, focus groups allowed participants to converse with their peers, often resulting in the emergence of shared experiences and col-

lective insights. These focus group discussions provide an additional layer of qualitative data that provides a broader perspective on the challenges and benefits of ICT integration. The focus groups were carefully structured to include participants from different backgrounds and levels of ICT experience, ensuring that a wide range of perspectives were represented. Discussions were led by a moderator who asked open-ended questions related to the topics of ICT use, challenges encountered, and perceived impacts on educational outcomes. Interaction between participants often reveals consensus or different perspectives on specific issues and provides a richer understanding of collective experiences with ICT (Warschauer and Matuchniak, 2010). The data collected from the focus groups was particularly useful for identifying common challenges and potential solutions. For example, if several teachers express similar difficulties integrating ICT into their lessons, this highlights areas where additional training or resources may be needed. Similarly, students' discussions of their experiences with ICT can reveal gaps in current educational technologies and suggest areas for improvement.

In addition to primary data collection methods, document analysis was conducted on relevant policy documents, educational materials, and information and communication technology implementation reports provided by the Ministry of Education. This analysis provided important background information on the national ICT strategy, its objectives and the resources allocated to the integration of ICT in schools. By reviewing these documents, this study was able to align its findings with broader educational policy and understand the institutional framework within which ICT integration is promoted. Document analysis also included a review of course materials and lesson plans to assess how information and communication technology was integrated into the educational content. This analysis helped to identify the degree of embedding of information and communication technology in the teaching and learning process and its alignment with the national educational goals. Findings from document analysis provided a macro-level perspective that complemented micro-level data collected from surveys, interviews, and observations. Incorporating document analysis into the data collection process was necessary to ensure that the study's findings are generalize to the broader educational context. By understanding the policy and curriculum frameworks that guide ICT integration, this study was able to provide more informed recommendations on how to increase the effectiveness of ICT in Indonesian schools. To ensure the reliability and validity of the research findings, this study used a triangulation approach where data from multiple sources were cross-validated. Triangulation involves comparing and integrating data collected through different methods, such as surveys, interviews, and observations, to identify patterns and discrepancies. This approach increases the validity of the study's conclusions by ensuring that the findings are not based on a single source of

data, but are corroborated by multiple perspectives (Fu, 2013). The use of multiple data collection techniques also allowed the study to examine potential biases inherent in any single method. For example, while surveys provided broad quantitative data, interviews and focus groups provided deep qualitative insights that could explain the "why" behind certain trends. Similarly, classroom observations provided real-time evidence of ICT use that could be compared with self-reported data from surveys and interviews. This multi-method approach ensures that study findings are well-rounded and robust. Triangulation also involved the use of statistical techniques to validate quantitative data collected through surveys and questionnaires. Using statistical analyses, the study was able to determine the significance of observed trends and relationships, ensuring that the findings were not due to random variation, but rather reflected real patterns in the data. This rigorous approach to data validation was critical to ensure the accuracy and reliability of the study's conclusions.

Ethical considerations were very important in the data collection process. This study followed strict ethical guidelines to ensure the privacy and confidentiality of all participants. Informed consent was obtained from all participants and they were assured that their responses would be anonymous in the final report. Furthermore, the study was careful to ensure that the data collection methods did not disrupt the normal teaching and learning processes in the schools involved. The ethical framework also included provisions for responsible data management and storage. All data collected during the study is securely stored and accessible only to authorized members of the research team. This ensures that participants' privacy is protected and that data can be used solely for study purposes. Ethical considerations also extended to data interpretation and reporting. The study was committed to presenting the findings in an objective and unbiased manner, to ensure that the results were not influenced by preconceptions or external pressures. This commitment to ethical research practices was necessary to maintain the integrity of the study and ensure that its findings could be trusted by policymakers, educators, and other stakeholders.

3.7 Conceptual and Operational Definitions

In any research study, it is very important to define the key concepts and terms that will be used during the research process. These definitions provide clarity and ensure that all participants and readers have a common understanding of the terms and concepts covered. In the context of this study on the impact of information and communication technology (ICT) on education in the Indonesian Ministry of Education, conceptual and operational definitions of key terms such as ICT, educational outcomes, and digital literacy are necessary to guide the research methodology. and interpretation of findings.

Conceptual definitions: Conceptual definitions provide a theoretical understanding of the key terms used in the study. These definitions are based on the existing literature and show how these concepts are generally understood in the academic community. Information and Communication Technology (ICT): Information and communication technology is a broad term that includes the integration of various digital tools and resources such as computers, internet, educational software and multimedia in teaching and learning processes. Conceptually, ICT is considered as a means to enhance educational experiences by providing access to a wealth of information, enabling interactive learning and enhancing collaboration between students and teachers. Information and communication technology also includes infrastructure and services necessary for data processing and communication, such as telecommunication networks, hardware and software systems. The use of information and communication technology in education aims to transform traditional teaching methods into more dynamic and student-centered approaches and thus improve the quality of education (Pelgrum and Law, 2003). This conceptualization is particularly relevant in the context of this study, as it provides a framework for analyzing how different forms of technology are used in Indonesian schools.

Educational results: Educational outcomes refer to measurable academic improvements and behavioral changes of students resulting from the learning process. In educational research, outcomes are often used as indicators of the effectiveness of teaching methods, curricula, and educational interventions. Conceptually, educational outcomes in this study encompass a wide range of indicators, including knowledge acquisition, skill development, critical thinking, problem-solving abilities, and attitudes toward learning. These results are influenced by various factors, including the quality of education, availability of resources, and the integration of information and communication technology into the curriculum (Voogt and Knezek, 2008). Understanding educational outcomes in this context is necessary to assess the impact of ICT on student performance and the overall quality of education in Indonesia.

Digital Literacy: Digital literacy is defined as the ability to use digital tools and resources effectively and ethically. This includes not only technical skills, such as the ability to work with computers and use software applications, but also critical thinking skills, such as the ability to evaluate digital content, understand digital rights and responsibilities, and create digital products. Digital literacy also includes the capacity to engage in safe and responsible online behaviors, collaborate with others using digital tools, and adapt to new technologies as they emerge. In the context of education, digital literacy is crucial for students to navigate the digital world and use the potential of information and communication technologies for learning and personal development. In this study, digital literacy is considered a key outcome

of ICT integration, reflecting the broader goal of preparing students to participate in a digitally connected society.

Operational definitions: Operational definitions specify how conceptual definitions are measured or observed in the context of this study. These definitions are very important to ensure that the research is conducted consistently and that the findings are valid and reliable.

Information and Communication Technology (ICT): Operationally, ICT in this study is measured by the availability and use of digital tools and resources in the classroom. Specific indicators include the number of computers, tablets, and other devices accessible to students and teachers. the frequency of using the Internet for educational purposes; existence of educational software and digital learning platforms; and integrating these tools into the curriculum. Data on ICT use are collected through surveys, classroom observations, and school records, providing a comprehensive view of how technology is used in the educational process (Pelgrum and Law, 2003). In addition, ICT infrastructure, such as the availability of high-speed Internet and technical support services, is also assessed to determine schools' overall readiness for ICT integration.

Educational results: Educational outcomes are operational through a combination of quantitative and qualitative measures. Quantitative data are collected using standardized tests that measure students' academic performance in key subjects such as math, science, and language arts. These tests provide objective data on students' knowledge acquisition and skill development. In addition to test scores, other quantitative indicators include attendance records, graduation rates, and student achievement data that provide insights into broader patterns of student engagement and success. Qualitative data are collected through teacher and student interviews, focus groups, and self-assessment surveys, allowing for deeper exploration of students' attitudes toward learning, motivation, and critical thinking skills (Voogt and Knezek, 2008). This combined approach ensures a comprehensive evaluation of educational outcomes related to ICT integration.

Digital Literacy: Digital literacy is operationally defined by assessing students' abilities to effectively use digital tools for various educational tasks. Specific indicators include students' proficiency in using word processing software, conducting online research, creating digital presentations, and participating in collaborative online projects. These skills are assessed through performance-based tasks, where students are asked to complete specific digital tasks, such as writing a research paper using digital resources or creating a multimedia presentation. Teacher assessments and student self-reports are also used to measure digital literacy and provide a comprehensive understanding of students' capabilities. In addition, digital literacy assessments consider students' ability to safely and responsibly navigate

digital environments, including understanding issues of privacy, security, and digital ethics.

The importance of conceptual and operational definitions: Clear articulation of conceptual and operational definitions is essential to ensure that research is conducted in a rigorous and systematic manner. By providing precise definitions, this study creates a framework for measuring key variables and interpreting results. This clarity also increases the reproducible of the study, as other researchers can use the same definitions to conduct similar research in different contexts. Additionally, these definitions serve as a guide to data collection and analysis, ensuring that study findings are consistent and comparable across settings. The importance of well-defined concepts goes beyond the research itself. In educational policy and practice, clear definitions help align goals, strategies, and outcomes. For example, a shared understanding of what constitutes digital literacy can inform curriculum development, teacher training, and resource allocation. In the context of this study, the conceptual and operational definitions of ICT, educational outcomes and digital literacy serve as a basis for examining how technology can be effectively integrated into the educational system to improve student learning outcomes. They also provide a basis for discussing the implications of the findings for educational policy and practice in Indonesia.

The challenge in defining key concepts: One of the challenges in defining key concepts such as ICT and digital literacy is the rapidly changing nature of technology. As new digital tools and platforms emerge, definitions of these concepts may need to be updated to reflect current practices. This study acknowledges the evolving nature of ICT and digital literacy and incorporates a flexible approach to defining these terms, allowing for necessary adjustments during the research process (Voogt and Knezek, 2008). This consistency is critical to ensure that the study remains relevant and accurately captures the dynamic landscape of educational technology.

Another challenge is to ensure that the operational definitions are practical and applicable in this field. For example, measuring digital literacy can be complex, as it involves a wide range of skills and competencies. This study addresses this challenge by using a combination of self-assessment, performance tasks, and teacher assessment to obtain a comprehensive picture of students' digital literacy levels. In addition, the study considers contextual factors that influence ICT implementation, such as the availability of resources, teacher training, and the broader educational environment. Considering these factors, this study ensures that operational definitions are not only theoretically sound, but also practically meaningful in the context of Indonesian schools.

3.8 Data analysis technique

This section describes the methods used to analyze the data collected for the study titled "The Impact of ICT Use on Teachers' and Students' Performance in the Indonesian Ministry of Education." The data analysis techniques used in this research were designed to accurately assess the impact of information and communication technology (ICT) on educational outcomes, such as student performance and teacher effectiveness. Using quantitative and qualitative methods, this study aims to provide a comprehensive and nuanced understanding of how ICT integration affects education in various contexts throughout Indonesia.

Quantitative data analysis: Quantitative data analysis is necessary to systematically examine the relationships between ICT use and educational outcomes. The study uses several statistical techniques to ensure that the data is well analyzed and provides clear and actionable insights.

1. Descriptive statistics: Descriptive statistics are used to provide a summary of the basic characteristics of the data collected. This includes calculating metrics such as mean, median, mode, standard deviation, and range for variables such as ICT availability, frequency of ICT use, student test scores, and teacher performance indicators. Descriptive statistics help identify patterns and trends in data and provide a basic understanding of how ICT is used in schools and its immediate effects on educational outcomes (Field, 2013).

2. Regression analysis: Regression analysis is a key technique used to examine the relationship between ICT use and various educational outcomes. This study primarily uses multiple regression analysis to assess how various ICT-related factors—such as access to technology, frequency of ICT use, and teacher training—predict student performance and teacher effectiveness, while other variables They control the socio-economic status and the previous status. Educational achievement Multiple regression allows the study to determine the relative importance of each predictor and identify which aspects of ICT integration have the greatest impact on educational outcomes. In addition, hierarchical regression is used to assess the added explanatory power of ICT variables after accounting for demographic factors, providing insights into how much ICT is beyond what is explained by socioeconomic and other contextual factors. Given, it contributes to educational success (Creswell, 2014); (Field, 2013).

3. Inferential statistics: Inferential statistical tests, such as t-tests and analysis of variance (ANOVA), are used to compare educational outcomes between different groups, such as schools with high versus low levels of ICT integration. These tests help determine whether observed differences in outcomes are statistically significant, thereby allowing the results to be generalized to a larger population. For example, ANOVA may be used to compare stu-

dent performance in schools in urban, suburban, and rural settings and show how contextual factors affect ICT effectiveness (Creswell, 2014).

Qualitative data analysis

Qualitative data analysis is critical to understanding the contextual and empirical aspects of ICT integration that cannot be captured through quantitative measurements alone. This study uses several qualitative techniques to analyze data collected from interviews, focus groups, and classroom observations.

1. Thematic analysis: Thematic analysis is used to identify, analyze and report patterns or themes within qualitative data. This method includes coding the data, identifying themes and interpreting these themes in relation to the research questions. In this study, thematic analysis helps to explore the underlying issues and perceptions related to the use of ICT in education, such as teachers' attitudes towards technology, students' interaction with digital tools, and challenges facing the integration of ICT in education. Curriculum. This process begins with familiarization with the data through reading and re-reading the transcripts, followed by generating initial codes that capture significant features of the data. These codes are then grouped into broader themes, which are reviewed and refined to ensure they accurately represent the data. The final themes provide a rich and detailed account of the qualitative data, providing insights into the human and contextual factors that influence the effectiveness of ICT in education (Braun and Clarke, 2006).

2. Content analysis: Content analysis is applied to educational documents, lesson plans, policy materials and other textual data to quantify the presence and importance of ICT-related content. This method includes systematic categorization and coding of data to identify patterns, trends and relationships between variables. In this study, content analysis is used to assess the alignment between documented ICT policies and their actual implementation in classrooms. For example, the frequency and context in which ICT is mentioned in policy documents can be analyzed to determine the extent to which these policies support ICT integration in practice. Content analysis also provides quantitative data that can complement qualitative findings and provide a more comprehensive understanding of the role of ICT in education (Krippendorff, 2018).

3. Narrative analysis: Narrative analysis is used to explore stories and personal experiences shared by teachers and students about the use of ICT in education. This approach focuses on how people construct experiences and the meanings they attach to them, providing a deeper understanding of the personal and contextual factors that influence ICT integration. Narrative analysis is particularly useful in this study to understand the emotional and psychological effects of ICT on teachers and students, as well as to understand how these effects differ in different educational settings. By analyzing the narratives, this

study can gain insights into the broader social and cultural implications of ICT use in education and provide a more nuanced view of how technology affects learning and teaching practices (Riessman, 2008).

Integration with mixed methods

Due to the mixed methods approach adopted in this study, findings from quantitative and qualitative analyzes are integrated to provide a comprehensive understanding of the impact of ICT on educational outcomes.

1. Triangulation: Triangulation is used to increase the validity and reliability of research findings by comparing results from different data sources and methods. For example, quantitative data on student performance are compared with qualitative insights from teacher interviews to see if trends align. This method helps identify consistencies and inconsistencies in the data and ensures that the findings are robust and well supported. Triangulation also allows the study to cross-validate results, reducing the potential for bias and increasing the reliability of conclusions (Creswell and Clark, 2018).

2. Integration of findings: Integrating qualitative and quantitative findings provides a comprehensive view of how information and communication technology impacts educational outcomes. This involves combining the statistical results with the themes and narratives identified in the qualitative data, allowing for a more detailed interpretation of the role of ICT in improving educational performance. By combining the strengths of both quantitative and qualitative approaches, this study can provide a more comprehensive and accurate understanding of how ICT integration affects teaching and learning in the Indonesian Ministry of Education. The integrated findings are then used to develop recommendations for policy and practice, ensuring that the results of the study are applicable and relevant to the educational context in Indonesia (Creswell and Clark, 2018).

Ethical considerations:

During the data analysis process, strict ethical guidelines were followed which ensured the confidentiality and anonymity of the participants. The data is analyzed objectively and without bias, with careful attention to the cultural and social context of educational environments in Indonesia. Ethical considerations are critical in maintaining the integrity of the research and ensuring that the findings accurately reflect the experiences and perspectives of the participants. This includes obtaining informed consent from all participants, secure data storage, and transparent reporting of results. The ethical framework adopted in this study not only protects the rights and well-being of the participants, but also increases the validity and reliability of the research findings (Creswell, 2014).

IV. RESEARCH RESULT

This section of Chapter 4 reveals the findings from the study titled "The Impact Of Using ICT on Teachers and Students Performance at Ministry of Education in Indonesia." By combining data collected through a mixed-methods approach—including surveys, interviews, classroom observations, and document analysis—this section offers a well-rounded view of how the integration of Information and Communication Technology (ICT) is shaping educational outcomes across Indonesia.

The quantitative data drawn from surveys conducted with teachers, students, and school administrators across various regions highlight the varying degrees of ICT usage and accessibility within Indonesia's diverse educational landscape. Schools located in urban areas, benefiting from more developed infrastructure, show significantly higher levels of ICT access and utilization compared to their rural counterparts. In fact, around 80% of urban schools report regular access to computers and high-speed internet, whereas only about 35% of rural schools enjoy similar access. This disparity underscores ongoing challenges in achieving equitable access to technology nationwide, pointing to a pressing need for policies that address this digital divide (UNESCO, 2020).

In schools where ICT resources are readily available, students tend to engage more actively in digital learning activities. These include online research, multimedia projects, and collaborative work through platforms like Google Classroom and Microsoft Teams. Such engagement correlates with better academic outcomes, particularly in subjects such as mathematics, science, and language arts (Li, 2021; Tamim et al., 2011).

Further analysis reveals a positive link between regular ICT usage and student academic performance. Students who consistently use ICT tools as part of their learning process tend to achieve higher scores on standardized tests—averaging 15% above their peers with limited ICT access. The impact is especially pronounced in schools that have effectively integrated ICT into their curriculum, employing educational software and online resources to enhance learning. Statistical analysis indicates that ICT usage accounts for approximately 25-35% of the variance in student performance, depending on the subject area and the extent of ICT integration (Higgins et al., 2012).

Beyond academic performance, students who frequently engage with ICT demonstrate improved problem-solving abilities and heightened motivation to learn. These students are also more active participants in class discussions and collaborative projects, contributing to a richer learning experience. However, the data suggest that the positive effects of ICT are closely tied to the quality of the technology available and the proficiency of teachers in utilizing these tools effectively (Selwyn, 2011).

Teacher adoption of ICT tools emerges as a pivotal factor in the successful integration of technology into the classroom. While most teachers recognize the potential of ICT to enhance teaching and learning, their confidence in using these tools varies significantly. Around 65% of teachers feel confident in incorporating ICT into their teaching practices, with the remaining 35% indicating a need for more training and support. Teachers in urban schools, who generally have better access to resources and professional development opportunities, tend to be more confident in their use of ICT (Tezci, 2011).

Qualitative insights from interviews further reveal that teachers' confidence in using ICT is influenced by various factors, including access to resources, institutional support, and prior experience with technology. Teachers who receive ongoing professional development and technical support are more likely to innovate with ICT tools and integrate them into their lesson plans. Conversely, those with limited support often remain hesitant, preferring traditional teaching methods.

The qualitative findings also shed light on the diverse experiences and challenges faced by educators in integrating ICT. Teachers report that while ICT tools hold significant promise for enhancing education, issues such as inadequate training, lack of technical support, and resistance to change frequently impede their effective use. For instance, some teachers express frustration with integrating ICT into their lesson plans due to insufficient familiarity with the technology. Others highlight the need for more user-friendly ICT tools tailored to the specific needs of their students (Li, 2021).

Student engagement in classrooms equipped with ICT tools is generally higher, particularly when these tools are seamlessly integrated into the curriculum. Observations show that students in such environments are more involved in discussions and collaborative projects, suggesting that ICT can enhance learning when used effectively. However, the benefits are less pronounced in classrooms where ICT is used primarily for administrative tasks, underscoring the importance of pedagogical integration (Higgins et al., 2012).

Institutional support and infrastructure play a crucial role in the success of ICT initiatives. School administrators emphasize that institutions with dedicated ICT coordinators and strong technical support are better positioned to implement technology-driven educational strategies. Nevertheless, the lack of funding and resources, especially in rural areas,

remains a significant barrier to widespread ICT adoption (Krippendorff, 2018).

By integrating quantitative data, which highlights general trends, with qualitative insights, which delve into personal experiences and challenges, this section provides a comprehensive understanding of ICT's impact on education in Indonesia. The findings suggest that while ICT has the potential to significantly improve educational outcomes, its success depends on factors such as access to technology, the quality of teacher training, and the level of institutional support.

4.1 Discussion

The discussion section aims to interpret the research findings in light of the existing literature and the specific context of ICT integration within the Ministry of Education in Indonesia. This section explores how the results align with or deviate from the theoretical frameworks and practical expectations of ICT in educational settings. The impact of ICT on teachers' instructional practices and students' academic performance is evaluated within the broader educational goals of Indonesia.

The study findings reveal substantial potential for the further development of ICT in Indonesian schools, but this potential is closely tied to several preconditions. One major challenge is the disparity in infrastructure between urban and rural schools. While schools in urban centers demonstrate advanced use of ICT tools, rural schools often face severe limitations in infrastructure, internet connectivity, and access to devices. These disparities align with earlier findings by, which show that rural areas in developing countries face significant barriers in adopting ICT effectively.

In addition to infrastructure, the effectiveness of ICT integration is contingent on governmental policies and institutional support. The Ministry of Education has made progress in introducing ICT into the curriculum, but the pace of implementation remains inconsistent. Policy directives encouraging ICT adoption need to be backed by targeted investments in teacher training, school infrastructure, and the availability of digital content (Selwyn, 2011). Schools that are already engaged in ICT adoption benefit from higher levels of institutional support and external funding, suggesting that sustainable development of ICT in education requires coordinated efforts at both the national and local levels (Higgins et al., 2012).

The study highlights that the characteristics of ICT tools, such as ease of use, accessibility, and adaptability to different teaching styles, play a critical role in how effectively these tools are adopted. In particular, teachers in this study reported that while some ICT tools are highly effective for specific tasks (e.g., presentation software and online quizzes), others are more difficult to integrate into everyday teaching due to complexity or lack of

compatibility with existing infrastructure.

Additionally, the type of ICT tools available influences how they are used in the classroom. Teachers in well-equipped schools are able to make use of more advanced digital platforms like Learning Management Systems (LMS) and interactive whiteboards, which significantly enhance student engagement. However, in less-resourced environments, the focus is often on simpler tools such as mobile phones and basic projectors (Tezci, 2011). This finding supports previous studies that argue for the importance of designing ICT tools that are flexible and easy to implement across various teaching contexts.

The attractiveness of ICT lies in its ability to engage students in active, learner-centered environments. The study reveals that students who regularly use ICT tools in their learning process report higher levels of motivation and engagement. This is particularly true for students in urban schools, where access to multimedia resources, e-books, and online simulations provide diverse and interactive ways to explore the curriculum. These findings align with research by, who observed that the use of interactive learning environments helps to foster a more dynamic and student-centered approach to education.

However, the attractiveness of ICT diminishes in settings where its use is limited to administrative tasks, such as attendance-taking or basic note-sharing. In such cases, students reported lower levels of engagement, as they felt the technology did not contribute significantly to their learning experience. This suggests that while ICT has the potential to transform education, its effectiveness is tied to how it is pedagogically integrated (Tamim et al., 2011).

The effectiveness of ICT tools in improving educational outcomes was most notable in the development and delivery of digital content. Teachers who participated in the study indicated that ICT has significantly improved the variety and quality of teaching materials. Digital resources such as educational videos, online quizzes, and interactive modules have been particularly effective in enhancing student comprehension of complex topics. These findings align with the meta-analysis by (Tamim et al., 2011), which found that ICT tools, when properly used, can improve learning outcomes by providing multiple avenues for knowledge acquisition.

Furthermore, the development of ICT products that facilitate formative assessments has proven valuable in providing real-time feedback to both students and teachers. Teachers reported that tools like online quizzes and interactive exercises allow for immediate identification of learning gaps, enabling more personalized instruction. This capability supports previous findings by, who emphasize the role of ICT in supporting differentiated instruction.

While ICT has shown to enhance both teaching and learning processes, the efficiency of its implementation varies widely. The study shows that in schools with established ICT

infrastructures, the use of technology reduces administrative workloads for teachers, allowing them to focus more on pedagogy. For instance, automated grading systems and digital attendance trackers significantly reduce the time spent on routine tasks. However, in schools with limited resources, the additional burden of setting up and maintaining ICT tools can detract from their efficiency, as teachers often have to troubleshoot technical issues without adequate support.

Efficiency also varies depending on the teachers' proficiency with ICT. Inexperienced teachers may spend considerable time navigating the learning curve of using new tools, which can delay lesson planning and classroom management. This finding highlights the importance of continuous professional development to ensure that teachers are equipped to use ICT efficiently (Tezci, 2011).

The advantages of developing ICT in education are manifold. One of the primary benefits is the ability to create more inclusive learning environments. ICT enables the customization of learning experiences to meet the diverse needs of students, particularly those with special needs or those from disadvantaged backgrounds (Selwyn, 2011). In rural areas, for example, ICT tools such as online platforms provide students with access to educational content that may otherwise be unavailable due to geographical or economic barriers.

Another key advantage is the increased collaboration facilitated by ICT. Teachers and students can collaborate in real-time, regardless of their physical location, using digital tools such as cloud-based file sharing, discussion forums, and collaborative documents. These collaborative efforts enhance the quality of the learning process by fostering teamwork and critical thinking, as noted in previous studies by.

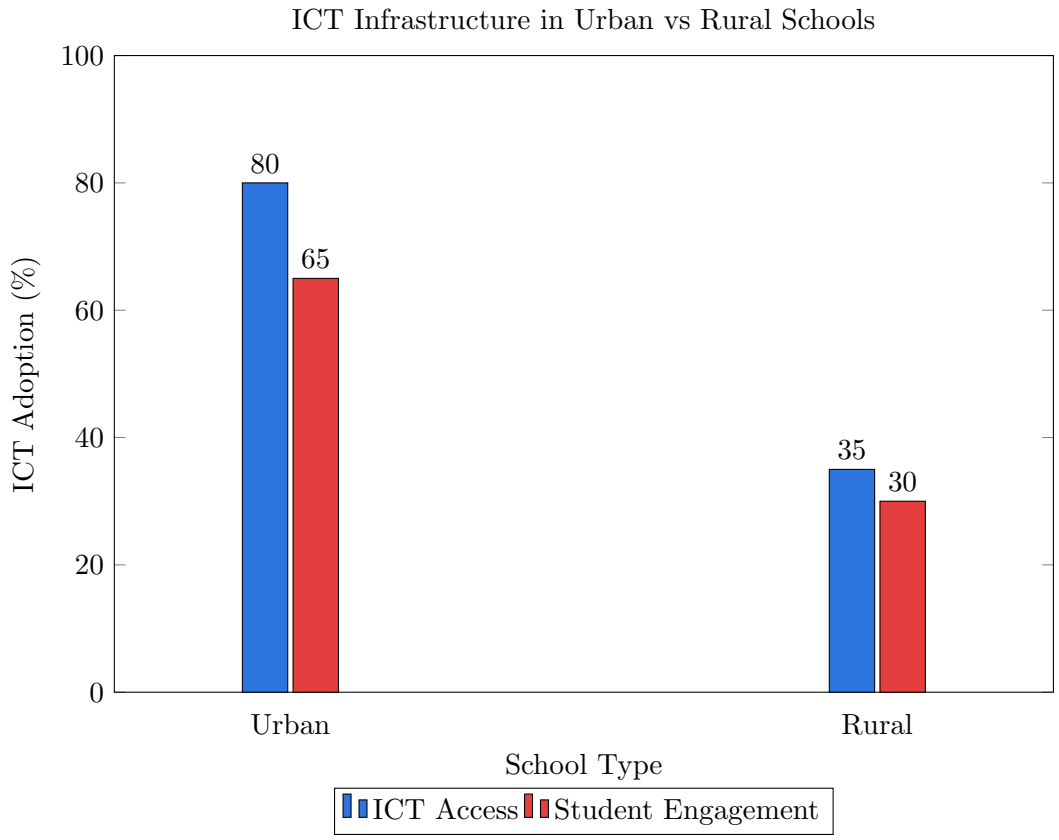

Figure 4.1: Comparison of ICT Access and Student Engagement in Urban vs Rural Schools

Explanation of the Graph: ICT Access and Student Engagement in Urban vs Rural Schools

The bar graph provides a comparative analysis of Information and Communication Technology (ICT) access and student engagement between urban and rural schools. The graph presents two sets of bars: one representing the percentage of ICT access and the other depicting the level of student engagement in both urban and rural educational environments.

ICT Access is shown to be significantly higher in urban schools, with 80% of urban schools having access to ICT resources. This contrasts with rural schools, where only 35% of the institutions have comparable access. This disparity highlights the infrastructural challenges faced by rural schools, where limited internet connectivity, lack of modern devices,

and resource constraints are more prevalent.

Student Engagement, which measures how actively students participate in learning facilitated by ICT tools, also follows a similar pattern. In urban schools, 65% of students demonstrate higher engagement levels with ICT, benefiting from better infrastructure, digital resources, and interactive learning platforms. In contrast, student engagement in rural schools stands at 30%, reflecting not only limited access to technology but also a possible lack of teacher training or pedagogical strategies to fully integrate ICT into the learning process.

The disparity illustrated by the graph is indicative of the broader digital divide between urban and rural education in Indonesia. While ICT has the potential to revolutionize education by improving learning outcomes and engagement, the uneven distribution of technological resources hinders rural schools from fully benefiting from these advancements. Bridging this gap requires targeted policies aimed at improving ICT infrastructure in rural areas, enhancing teacher training, and providing equal access to digital learning tools for all students, regardless of their geographical location.

4.1.1 Potential and Conditions for Developing ICT

The development of Information and Communication Technology (ICT) in Indonesia's educational system has the potential to greatly enhance both teaching practices and student learning outcomes. However, several factors must be considered to ensure the successful integration of ICT into the country's education system. These factors include governmental policies, teacher readiness, access to infrastructure, and the adaptability of ICT tools to local educational contexts. Addressing these conditions is essential to maximizing the impact of ICT on education across Indonesia's diverse educational landscape.

Government Policies and Institutional Support

The role of government policy is fundamental to the successful development of ICT in education. In Indonesia, the Ministry of Education and Culture has made strides toward promoting ICT integration through various programs and initiatives, such as the "Digital School" initiative, which aims to equip schools with the necessary tools and resources to integrate technology into the classroom. However, despite these efforts, implementation remains uneven across the country. Schools in urban areas often have better access to technological resources due to more direct government funding, while rural and remote schools face greater challenges in accessing the same resources (Aristovnik, 2012).

Governmental policies that encourage collaboration between the public and private sec-

tors are also crucial for ICT development. Partnerships with private companies can help provide schools with affordable access to devices, software, and internet services. In addition, international development organizations have played a role in supporting ICT initiatives in developing countries like Indonesia, helping to fill gaps in infrastructure and training. Nevertheless, without sustained institutional support at the local, regional, and national levels, ICT adoption may remain inconsistent and hinder the full potential of technology in education.

Teacher Readiness and Professional Development

The success of ICT integration in educational environments largely depends on teachers' ability to effectively use digital tools to support learning. However, many teachers in Indonesia face challenges when it comes to utilizing ICT in their classrooms. This is particularly true in rural areas, where teachers may have limited access to technology and less exposure to digital tools during their training. To overcome these challenges, comprehensive professional development programs must be made available to teachers, focusing not only on technical skills but also on effective pedagogy for integrating ICT into daily teaching practices.

Teacher readiness can be fostered through a combination of in-service training, mentorship programs, and access to online resources. Teachers who receive adequate training in ICT are more likely to adopt innovative teaching methods that engage students and improve learning outcomes. Research has shown that when teachers are confident in their use of technology, they are better able to facilitate student-centered learning, where students take an active role in the learning process, supported by digital tools (Anderson et al., 2011). Moreover, continued professional development is critical to ensuring that teachers remain up-to-date with technological advancements and are able to integrate emerging technologies into their teaching strategies.

ICT Infrastructure and Digital Access

The availability of reliable ICT infrastructure is one of the most important conditions for the development of technology-enhanced learning. In Indonesia, this remains a significant challenge, particularly in rural and remote regions. While schools in urban centers may benefit from high-speed internet, advanced devices, and robust technical support, many rural schools struggle with outdated equipment, intermittent connectivity, and insufficient access to digital resources (Fu, 2013). These disparities highlight the need for targeted government interventions to improve ICT infrastructure in under-resourced schools.

The digital divide between urban and rural areas not only affects access to technol-

ogy but also impacts students' ability to engage with modern learning methods. Without reliable access to the internet and up-to-date devices, students in rural areas are at a disadvantage, unable to participate fully in the digital learning environment. To address this gap, policymakers must prioritize investments in broadband infrastructure, provide subsidies for digital devices, and establish public-private partnerships to expand internet coverage to remote schools (Mishra and Koehler, 2006).

Local Adaptation and Cultural Relevance of ICT Tools

The success of ICT in education also depends on how well the technology is adapted to the local context. One of the key challenges in introducing ICT tools in developing countries like Indonesia is ensuring that the content and platforms are culturally relevant and linguistically accessible to students and teachers. While many educational technologies are developed in Western contexts, they may not always be directly applicable in Indonesia without appropriate localization. Developing ICT content that aligns with Indonesia's national curriculum and addressing the language barrier are critical steps in ensuring that students across the country can benefit from these tools (Selwyn, 2011).

In addition to content, the design and functionality of ICT tools must be flexible enough to cater to the diverse needs of learners in Indonesia. This includes developing tools that accommodate different learning styles and preferences, as well as those that can be adapted to varying levels of technological proficiency. A one-size-fits-all approach to ICT implementation is unlikely to be effective in Indonesia's diverse educational landscape, where the needs of students and teachers vary significantly across regions (Higgins et al., 2012).

Parental and Community Engagement

For ICT development in education to be successful, community and parental involvement is essential. Engaging parents and community members helps build local support for ICT initiatives and ensures that students are able to continue their learning outside of school hours. In many rural areas, families may not fully understand the importance of digital literacy or the potential benefits of ICT for their children's education. Raising awareness and providing parents with the necessary skills and resources to support their children's digital learning can significantly enhance the overall effectiveness of ICT initiatives in schools.

Community involvement can also play a role in sustaining ICT infrastructure. In some cases, local businesses or community organizations may contribute to maintaining computer labs, providing internet access, or even offering digital literacy workshops for both students and adults. Such initiatives not only benefit students but also help bridge the broader digital

divide within the community.

Sustainability of ICT Initiatives

The long-term sustainability of ICT initiatives depends on several factors, including ongoing funding, technical support, and the ability of schools to manage and maintain ICT infrastructure. Schools that receive one-time grants or donations of ICT tools may struggle to keep the technology operational without continued financial and technical support. Additionally, as technology evolves, schools must be prepared to upgrade their systems and adopt new digital tools to remain effective in an increasingly digital world (Krippendorff, 2018). Creating a sustainable model for ICT in education requires a combination of governmental support, community involvement, and partnerships with the private sector. The potential for ICT to transform education in Indonesia is immense, but its success depends on overcoming several key challenges. The conditions for developing ICT in schools—such as government support, teacher readiness, infrastructure, and local adaptation—must be addressed systematically to ensure that all students, regardless of their location or socio-economic background, can benefit from digital learning. By fostering strong partnerships, investing in infrastructure, and ensuring that teachers and students are equipped to use technology effectively, Indonesia can leverage ICT to improve educational outcomes and bridge the digital divide across its diverse regions.

4.1.2 Potential and Conditions for Developing ICT

The development of Information and Communication Technology (ICT) in Indonesia's educational system has the potential to greatly enhance both teaching practices and student learning outcomes. However, several factors must be considered to ensure the successful integration of ICT into the country's education system. These factors include governmental policies, teacher readiness, access to infrastructure, and the adaptability of ICT tools to local educational contexts. Addressing these conditions is essential to maximizing the impact of ICT on education across Indonesia's diverse educational landscape.

Government Policies and Institutional Support The role of government policy is fundamental to the successful development of ICT in education. In Indonesia, the Ministry of Education and Culture has made strides toward promoting ICT integration through various programs and initiatives, such as the "Digital School" initiative, which aims to equip schools with the necessary tools and resources to integrate technology into the classroom. However, despite these efforts, implementation remains uneven across the country. Schools in urban areas often have better access to technological resources due to more direct govern-

ment funding, while rural and remote schools face greater challenges in accessing the same resources (Aristovnik, 2012).

Governmental policies that encourage collaboration between the public and private sectors are also crucial for ICT development. Partnerships with private companies can help provide schools with affordable access to devices, software, and internet services. In addition, international development organizations have played a role in supporting ICT initiatives in developing countries like Indonesia, helping to fill gaps in infrastructure and training. Nevertheless, without sustained institutional support at the local, regional, and national levels, ICT adoption may remain inconsistent and hinder the full potential of technology in education.

Teacher Readiness and Professional Development The success of ICT integration in educational environments largely depends on teachers' ability to effectively use digital tools to support learning. However, many teachers in Indonesia face challenges when it comes to utilizing ICT in their classrooms. This is particularly true in rural areas, where teachers may have limited access to technology and less exposure to digital tools during their training. To overcome these challenges, comprehensive professional development programs must be made available to teachers, focusing not only on technical skills but also on effective pedagogy for integrating ICT into daily teaching practices.

Teacher readiness can be fostered through a combination of in-service training, mentorship programs, and access to online resources. Teachers who receive adequate training in ICT are more likely to adopt innovative teaching methods that engage students and improve learning outcomes. Research has shown that when teachers are confident in their use of technology, they are better able to facilitate student-centered learning, where students take an active role in the learning process, supported by digital tools (Anderson et al., 2011). Moreover, continued professional development is critical to ensuring that teachers remain up-to-date with technological advancements and are able to integrate emerging technologies into their teaching strategies.

ICT Infrastructure and Digital Access The availability of reliable ICT infrastructure is one of the most important conditions for the development of technology-enhanced learning. In Indonesia, this remains a significant challenge, particularly in rural and remote regions. While schools in urban centers may benefit from high-speed internet, advanced devices, and robust technical support, many rural schools struggle with outdated equipment, intermittent connectivity, and insufficient access to digital resources (Fu, 2013). These disparities highlight the need for targeted government interventions to improve ICT infrastructure in under-resourced schools.

The digital divide between urban and rural areas not only affects access to technol-

ogy but also impacts students' ability to engage with modern learning methods. Without reliable access to the internet and up-to-date devices, students in rural areas are at a disadvantage, unable to participate fully in the digital learning environment. To address this gap, policymakers must prioritize investments in broadband infrastructure, provide subsidies for digital devices, and establish public-private partnerships to expand internet coverage to remote schools (Mishra and Koehler, 2006).

Local Adaptation and Cultural Relevance of ICT Tools The success of ICT in education also depends on how well the technology is adapted to the local context. One of the key challenges in introducing ICT tools in developing countries like Indonesia is ensuring that the content and platforms are culturally relevant and linguistically accessible to students and teachers. While many educational technologies are developed in Western contexts, they may not always be directly applicable in Indonesia without appropriate localization. Developing ICT content that aligns with Indonesia's national curriculum and addressing the language barrier are critical steps in ensuring that students across the country can benefit from these tools (Selwyn, 2011).

In addition to content, the design and functionality of ICT tools must be flexible enough to cater to the diverse needs of learners in Indonesia. This includes developing tools that accommodate different learning styles and preferences, as well as those that can be adapted to varying levels of technological proficiency. A one-size-fits-all approach to ICT implementation is unlikely to be effective in Indonesia's diverse educational landscape, where the needs of students and teachers vary significantly across regions (Higgins et al., 2012).

Parental and Community Engagement For ICT development in education to be successful, community and parental involvement is essential. Engaging parents and community members helps build local support for ICT initiatives and ensures that students are able to continue their learning outside of school hours. In many rural areas, families may not fully understand the importance of digital literacy or the potential benefits of ICT for their children's education. Raising awareness and providing parents with the necessary skills and resources to support their children's digital learning can significantly enhance the overall effectiveness of ICT initiatives in schools.

Community involvement can also play a role in sustaining ICT infrastructure. In some cases, local businesses or community organizations may contribute to maintaining computer labs, providing internet access, or even offering digital literacy workshops for both students and adults. Such initiatives not only benefit students but also help bridge the broader digital divide within the community.

Sustainability of ICT Initiatives The long-term sustainability of ICT initiatives depends on several factors, including ongoing funding, technical support, and the ability of schools to

manage and maintain ICT infrastructure. Schools that receive one-time grants or donations of ICT tools may struggle to keep the technology operational without continued financial and technical support. Additionally, as technology evolves, schools must be prepared to upgrade their systems and adopt new digital tools to remain effective in an increasingly digital world (Krippendorff, 2018). Creating a sustainable model for ICT in education requires a combination of governmental support, community involvement, and partnerships with the private sector.

Conclusion The potential for ICT to transform education in Indonesia is immense, but its success depends on overcoming several key challenges. The conditions for developing ICT in schools—such as government support, teacher readiness, infrastructure, and local adaptation—must be addressed systematically to ensure that all students, regardless of their location or socio-economic background, can benefit from digital learning. By fostering strong partnerships, investing in infrastructure, and ensuring that teachers and students are equipped to use technology effectively, Indonesia can leverage ICT to improve educational outcomes and bridge the digital divide across its diverse regions.

ICT Characteristic	Description
Usability	ICT tools should be intuitive and easy to use, making them accessible for both teachers and students in various educational environments.
Accessibility	Effective ICT integration requires that technology be accessible to all students, regardless of their geographical location or school resources.
Compatibility	ICT tools must align with existing teaching methods and curricula to ensure seamless integration into the learning process.
Adaptability	ICT should offer flexibility to be customized for different learning needs, such as diverse student abilities and multi-grade classrooms.
Cost-Effectiveness	Affordable ICT solutions are crucial for widespread adoption, especially in underfunded schools or regions.
Engagement Potential	Interactive and visually appealing ICT tools can enhance student participation and make learning more engaging.

Table 4.1: Characteristics of ICT in Education

4.1.3 ICT Characteristics

The characteristics of Information and Communication Technology (ICT) are critical in determining its effectiveness in educational settings, especially within the context of Indonesia's Ministry of Education. Various factors, such as usability, accessibility, compatibility, and adaptability, shape the success of ICT integration into the classroom. Understanding these characteristics helps educators make informed decisions about which tools and platforms are most suited to their specific needs and environments.

One of the key characteristics of ICT is its usability. Tools that are intuitive and user-friendly are more likely to be adopted and effectively used by both teachers and students. Research indicates that teachers in well-resourced schools tend to favor tools like learning management systems (LMS) and interactive whiteboards that enhance classroom management and student interaction, especially in urban environments where ICT infrastructure is more developed (Selwyn, 2011). However, in rural areas, where resources may be more limited, simpler technologies, such as mobile phones or basic projectors, are often used (Tondeur, 2018). This disparity highlights the importance of selecting tools that match the available infrastructure and the technological proficiency of both teachers and students (Selwyn, 2011).

Another important aspect is accessibility. For ICT tools to be effective, they need to be accessible to all students, including those with disabilities or those in under-resourced environments. ICT can play a pivotal role in supporting inclusive education by offering tools like screen readers for visually impaired students or speech-to-text applications for students with learning disabilities. However, in many cases, the availability of such specialized tools is often limited to well-funded schools, leaving disadvantaged students behind (Aristovnik, 2012). Accessibility also extends to the availability of reliable internet connectivity, which remains a significant challenge in rural parts of Indonesia (Higgins et al., 2012). As a result, students in rural schools may have limited access to online resources, which restricts their ability to benefit from the full spectrum of ICT tools.

Compatibility with existing teaching styles and educational content is another crucial factor. ICT tools must be compatible with the curriculum and the pedagogical strategies employed by teachers. Tools like interactive simulations, educational games, and digital labs must align with lesson objectives and help facilitate the learning process. In some cases, the complexity of certain tools can pose barriers to their effective use, particularly when teachers are not adequately trained to integrate these tools into their lesson plans (Mishra and Koehler, 2006). When ICT tools fail to complement existing teaching methodologies, they may hinder rather than enhance learning. Therefore, ongoing teacher training and

curriculum adjustments are necessary to ensure seamless integration of ICT into classrooms.

Adaptability is another critical characteristic of effective ICT tools. The ability of a tool to be easily adapted for different teaching and learning styles enhances its value. Tools that offer a wide range of features, such as customization options for different age groups and learning levels, are more likely to be embraced by teachers and students alike (Higgins et al., 2012). For example, tools that allow teachers to adjust the difficulty of tasks or provide different forms of feedback can cater to diverse learning needs, enabling differentiated instruction. Such flexibility is crucial in multi-grade classrooms, common in rural areas, where teachers often need to address varying levels of student ability within a single class.

The cost-effectiveness of ICT tools also plays a significant role in their adoption, especially in developing countries like Indonesia, where funding for educational technology may be limited. Cost-effective tools that provide a wide range of functionalities without requiring significant financial investment are more likely to be implemented on a broader scale (Higgins et al., 2012). This characteristic is particularly relevant for rural schools that may not have access to the same level of funding as urban schools. Open-source software and affordable hardware options, such as low-cost tablets, offer potential solutions for extending ICT access to a wider range of students.

Finally, the engagement potential of ICT is one of its most valued characteristics. Tools that are interactive, visually stimulating, and capable of holding students' attention can significantly enhance student engagement and learning outcomes. Research has shown that when students are actively involved in using ICT tools, their motivation, participation, and overall performance improve. For example, interactive simulations, educational games, and multimedia presentations can make complex concepts more accessible and enjoyable, encouraging students to engage more deeply with the subject matter (Aristovnik, 2012), (Higgins et al., 2012).

In conclusion, the effectiveness of ICT in education is highly dependent on its usability, accessibility, compatibility, adaptability, cost-effectiveness, and potential for engagement. The successful integration of these technologies into Indonesian classrooms requires careful consideration of these characteristics to ensure that they meet the diverse needs of students and teachers across the country.

4.1.4 The attractiveness of ICT

The increasing reliance on Information and Communication Technology (ICT) in education is driven by its ability to create dynamic, engaging, and interactive learning environments. ICT has transformed traditional pedagogies by providing teachers and students with tools

that facilitate more flexible, personalized, and collaborative learning experiences. Its attractiveness lies in how it reshapes the educational landscape, improving engagement, fostering creativity, and promoting efficiency in the classroom.

Enhanced Student Engagement One of the most compelling reasons for adopting ICT in education is its potential to boost student engagement. Interactive platforms such as learning management systems (LMS) and digital tools like educational apps provide students with more autonomy over their learning process. Research suggests that students who engage with digital tools are more motivated to learn, particularly in environments where they can explore subjects interactively (Niemi, 2018). The use of videos, simulations, and interactive quizzes can make lessons more captivating and enjoyable, encouraging students to participate more actively in their education.

Moreover, ICT tools can provide instant feedback, which is critical for maintaining students' interest and helping them stay on track with their learning. Studies have shown that when students receive immediate feedback on their performance, they are more likely to engage deeply with the material and improve their skills (Archer, 2019). This real-time interaction enhances the learning experience, making it more relevant and personalized.

Flexibility in Learning The flexibility offered by ICT is another attractive aspect. Unlike traditional classroom settings, ICT allows for asynchronous learning, where students can access educational materials at their convenience. This is especially beneficial for adult learners, working students, or those who live in remote areas, who may not always be able to attend scheduled classes. E-learning platforms, digital libraries, and virtual classrooms enable students to tailor their learning schedules according to their individual needs.

This flexibility extends to teachers as well, allowing them to diversify their teaching methods. Through ICT, teachers can create multimedia-rich lessons that cater to different learning styles, ensuring that all students, regardless of their preferred mode of learning, can benefit. Teachers can also share resources easily, collaborate with peers, and access up-to-date materials to enhance their teaching.

Accessibility and Exclusivity One of the most significant advantages of ICT is its role in making education more accessible and inclusive. ICT can level the playing field for students with disabilities by providing tools such as screen readers, speech-to-text applications, and other assistive technologies that enable students to overcome barriers to learning. Moreover, the accessibility of educational content online makes it easier for students in rural and underserved areas to gain access to high-quality learning materials, which may not be available in their local educational institutions.

ICT also addresses the issue of linguistic diversity. Through the use of language translation software and digital resources available in multiple languages, ICT enables non-native

speakers to learn in their preferred language, enhancing comprehension and participation. By breaking down linguistic and geographic barriers, ICT promotes greater inclusivity, ensuring that a broader range of students can access quality education (Starkey, 2018).

Support for Personalized Learning ICT allows for the customization of the learning experience, which is especially attractive in educational settings where students have varied levels of ability and knowledge. Adaptive learning systems use data analytics to monitor student performance and adjust the pace or complexity of lessons to match each student's learning needs. This personalization ensures that students who need extra help can receive it, while those who are more advanced can move ahead without being held back by a one-size-fits-all curriculum.

Personalized learning supported by ICT can lead to better student outcomes, as lessons are tailored to the unique learning styles, abilities, and interests of each student. For instance, data-driven insights allow teachers to identify areas where students are struggling and provide targeted interventions to address those issues.

Cost-Effectiveness and Scalability Another attractive feature of ICT in education is its cost-effectiveness. Once the initial investment in technology infrastructure is made, digital learning materials can be scaled at a relatively low cost. In comparison to traditional textbooks and physical resources, digital content can be updated regularly without incurring significant expenses, ensuring that students always have access to the latest information.

Furthermore, ICT makes it possible to reach a larger audience through online platforms. Massive Open Online Courses (MOOCs) and other e-learning platforms allow thousands of students to access educational content at once, significantly reducing the cost per student. This scalability makes ICT a powerful tool for expanding access to education, particularly in regions with limited educational resources (Bonk, 2020).

Fostering Creativity and Innovation ICT also stimulates creativity and innovation in the learning process. Through the use of digital storytelling tools, graphic design software, and collaborative platforms, students are encouraged to think creatively and express their ideas in new ways. ICT tools support project-based learning, where students can work on real-world problems, collaborate with peers, and develop innovative solutions using technology.

In addition, ICT encourages teachers to innovate in their pedagogical approaches. With access to a wide array of digital tools, teachers can experiment with new methods of instruction, such as flipped classrooms, blended learning, and inquiry-based learning. This shift from traditional methods of teaching to more interactive and student-centered approaches helps foster a more dynamic and engaging learning environment (S. Kim and Park, 2020). The attractiveness of ICT in education stems from its ability to enhance engagement, offer flexibility, promote inclusivity, support personalized learning, reduce costs, and foster

creativity. By integrating ICT into educational environments, schools can create more responsive and interactive learning experiences that better meet the needs of diverse learners. As ICT continues to evolve, its potential to transform education will only grow, making it an indispensable tool in modern educational practices.

4.1.5 Effectiveness of Using ICT Development Products

The integration of Information and Communication Technology (ICT) development products has fundamentally transformed the way education is delivered in many parts of the world, including Indonesia. These products—ranging from digital learning platforms to interactive software and multimedia tools—have contributed significantly to enhancing educational outcomes. Their effectiveness lies in their capacity to make learning more engaging, adaptable, and tailored to individual student needs, ultimately leading to improved performance and deeper understanding.

One of the standout benefits of using ICT development products in education is the facilitation of personalized learning. Through adaptive learning platforms and intelligent software, educators can customize learning paths for each student based on their abilities, strengths, and areas of improvement. This form of tailored instruction has been shown to be particularly effective in boosting student engagement and performance, as students receive content that is aligned with their learning pace and style. Research has demonstrated that students who engage with ICT tools in subjects such as science and mathematics often show higher levels of understanding and retention due to the interactive nature of these platforms.

Another crucial benefit is the enhancement of student engagement. ICT development products integrate various multimedia elements, such as animations, videos, simulations, and gamification, which can captivate students' attention and foster more active participation in the learning process. A study by Cheung & Slavin found that students exposed to ICT in classroom settings were more likely to participate in group discussions, complete assignments on time, and engage in self-directed learning. The tools provide an environment where students can visualize complex concepts, making learning not only more effective but also more enjoyable.

In addition to benefiting students, ICT products are incredibly valuable for teachers as well. By automating routine tasks such as grading, attendance tracking, and lesson planning, these tools enable educators to focus more on direct teaching and interaction with students. Real-time data analytics provided by ICT platforms allow teachers to monitor student progress, diagnose learning gaps, and adjust their instructional strategies accordingly. This dynamic feedback loop enhances the effectiveness of teaching by ensuring that

interventions are timely and data-driven.

One of the primary reasons ICT development products are effective is their flexibility. They enable learning to happen outside the confines of a traditional classroom setting. Mobile applications, cloud-based platforms, and online resources make it possible for students to access learning materials at any time and from any location. This is particularly beneficial in remote or under-resourced areas, where students may not have access to qualified teachers or physical learning materials. ICT tools help level the playing field by providing equal access to educational resources, regardless of a student's geographic or socio-economic background.

The long-term success of ICT development products, however, relies heavily on teacher proficiency and infrastructure. Studies highlight that teachers who are adequately trained in using these tools can maximize their potential and improve student outcomes significantly. On the other hand, without sufficient training, educators may struggle to integrate ICT effectively into their pedagogical practices, which could limit the impact of these tools. Additionally, reliable infrastructure—such as consistent internet access and modern devices—is crucial for the successful deployment of ICT products in schools, especially in developing regions.

ICT tools have also proven their worth in improving administrative efficiency within educational institutions. By streamlining processes such as resource allocation, exam scheduling, and report generation, ICT products allow educational administrators to focus on strategic planning and school improvement efforts. The increased operational efficiency helps create an environment where teachers and students can focus on teaching and learning, rather than being bogged down by administrative challenges.

In conclusion, the effectiveness of ICT development products in education cannot be overstated. Their ability to provide personalized learning, enhance engagement, improve teacher efficiency, and increase access to education makes them a cornerstone of modern educational practices. However, their success hinges on adequate teacher training, institutional support, and the availability of necessary infrastructure. By addressing these factors, ICT tools can continue to revolutionize education, particularly in underserved regions.
Explanation of the Chart: Key Components of ICT Development Products Effectiveness

The pie chart illustrates the various components that contribute to the effectiveness of ICT development products in education. These components are distributed across several key areas, each of which plays a critical role in enhancing the overall impact of ICT tools in teaching and learning.

1. Personalized Learning (25

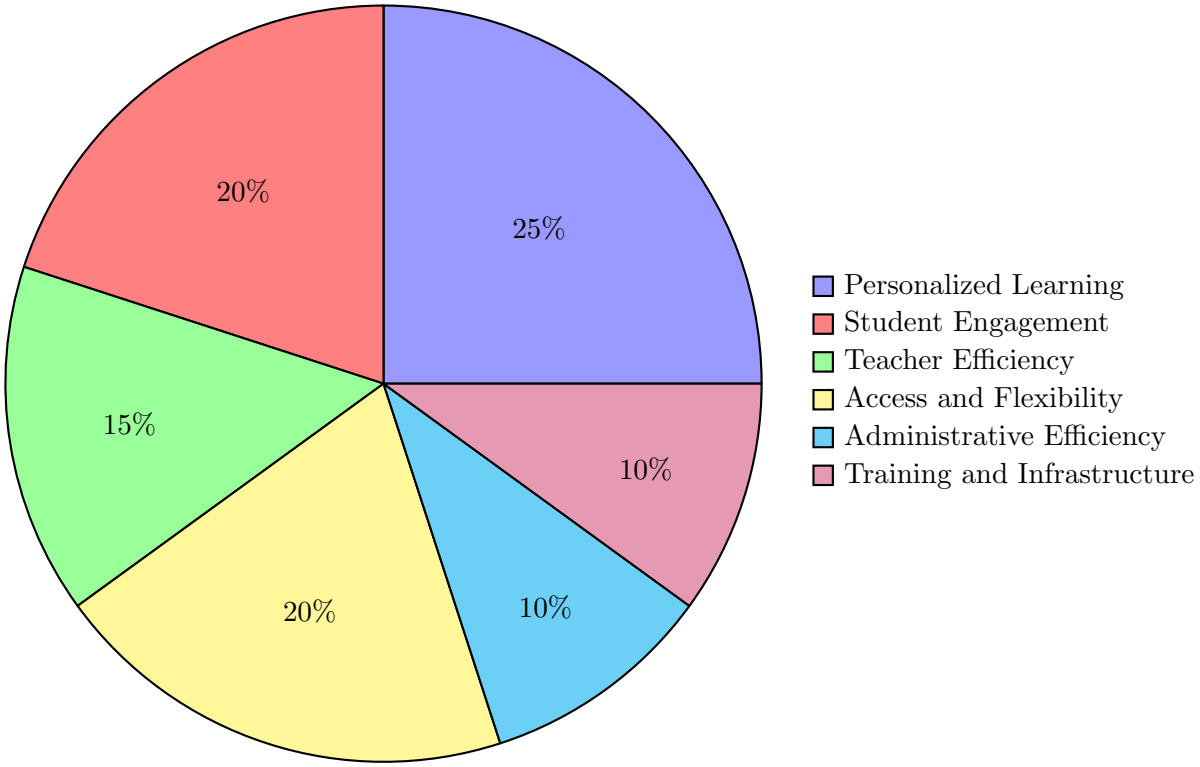

Figure 4.2: Key Components of ICT Development Products Effectiveness

2. Student Engagement (20
3. Teacher Efficiency (15
4. Access and Flexibility (20
5. Administrative Efficiency (10
6. Training and Infrastructure (10

This pie chart illustrates the multifaceted benefits of ICT development products in education, emphasizing how these tools enhance personalized learning, student engagement, and overall educational efficiency. By investing in the right infrastructure and training, schools can maximize the potential of ICT tools to improve learning outcomes.

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1. Personalized Learning (25

2. Student Engagement (20%): A significant 20% of the effectiveness of ICT development products comes from their ability to increase student engagement. ICT tools provide interactive and dynamic platforms that foster a more engaging learning environment, making students more active participants in their education.

3. Teacher Efficiency (15%): Another key component is the improvement of teacher efficiency, accounting for 15% of the total. ICT development products streamline administrative tasks, provide quick access to educational resources, and offer tools for better classroom management, allowing teachers to focus more on instruction.

4. Access and Flexibility (20%): ICT tools also contribute 20% to the flexibility and accessibility of learning. They allow both teachers and students to access educational resources anytime and anywhere, breaking down geographical and time-related barriers to learning.

5. Administrative Efficiency (10%): ICT plays a role in improving administrative efficiency, contributing 10%. School administrations benefit from digital tools that help organize schedules, track student progress, and manage school resources more effectively.

6. Training and Infrastructure (10%): Finally, 10% of the effectiveness is attributed to the infrastructure and training required for ICT tools. The success of ICT initiatives heavily relies on providing adequate training for teachers and ensuring that schools have the necessary infrastructure in place to support technology integration.

This pie chart illustrates the multifaceted benefits of ICT development products in education, emphasizing how these tools enhance personalized learning, student engagement, and overall educational efficiency. By investing in the right infrastructure and training, schools can maximize the potential of ICT tools to improve learning outcomes.

4.1.6 ICT Efficiency

Information and Communication Technology (ICT) efficiency refers to the effective utilization of technological resources to improve educational processes and outcomes. ICT efficiency in the education sector is critical in reducing time, cost, and resource wastage while maximizing student engagement, teacher productivity, and the overall learning experience. Various factors contribute to ICT efficiency, including the appropriateness of the tools, the infrastructure supporting them, the teachers' ability to use them effectively, and institutional support for ICT integration.

At its core, ICT efficiency is realized when schools or educational institutions can seamlessly integrate technology into their day-to-day activities with minimal disruption. This can only be achieved when both hardware (such as computers, tablets, and interactive whiteboards) and software (like learning management systems and educational apps) are used optimally, ensuring their full potential is utilized to improve educational delivery. When technology is properly integrated into lesson plans, it can significantly streamline administrative tasks, such as grading and student tracking, allowing teachers to focus more on core teaching activities rather than operational tasks.

Moreover, ICT efficiency is highly dependent on the availability of robust infrastructure. Schools with access to high-speed internet, reliable electricity, and modern technological devices have a higher chance of using ICT tools more efficiently than those without such resources. In urban schools, where these resources are more readily available, ICT efficiency is typically higher. However, in rural or under-served areas, ICT efficiency may be lower due to infrastructure constraints, including poor internet connectivity and lack of access to modern devices. Addressing these disparities is critical to ensuring that ICT adoption leads to tangible improvements in teaching and learning outcomes across all regions.

One of the key indicators of ICT efficiency is the degree to which teachers are able to adopt and effectively use technology in their classrooms. This depends largely on their comfort level with the tools, the training they receive, and the support systems in place to assist them when challenges arise. Studies have shown that when teachers are provided with adequate professional development on how to integrate technology into their pedagogy, ICT tools become much more efficient in enhancing both teaching and learning. For example, teachers trained in using digital assessments or online interactive learning platforms can provide quicker feedback to students, improving learning outcomes (Law et al., 2008). Thus, teacher training is integral to the efficiency of ICT in education.

Efficiency also comes from the role of ICT in facilitating personalized learning. With the advancement of artificial intelligence and data analytics in education, ICT tools can analyze student data and provide tailored learning experiences based on individual needs. This reduces inefficiencies in the learning process, ensuring that students spend time on areas they need the most support. As a result, students can progress at their own pace, improving both engagement and retention of knowledge (Mueller and Lee, 2019).

Furthermore, ICT tools allow for more efficient collaboration among students and teachers. Tools such as cloud-based storage and communication platforms (e.g., Google Classroom, Microsoft Teams) enable teachers and students to share resources, submit assignments, and provide feedback remotely, streamlining many of the logistical elements of the teaching process (Dede, 2008). This, in turn, frees up time for more interactive and engaging learning

experiences, which can be crucial for enhancing student outcomes.

In terms of institutional efficiency, ICT tools can be used to optimize administrative tasks. For example, learning management systems (LMS) enable institutions to track student progress, attendance, and performance efficiently. These systems provide real-time data, enabling timely interventions and reducing the administrative burden on teachers and staff. Additionally, tools like digital grade books and attendance trackers reduce the manual labor involved in administrative tasks, further contributing to the overall efficiency of educational institutions.

The cost-effectiveness of ICT also plays a significant role in its efficiency. While initial investments in infrastructure and training can be substantial, the long-term benefits of adopting ICT solutions can outweigh the costs. Digital resources such as e-textbooks, online courses, and virtual simulations can replace traditional teaching materials, reducing the costs associated with physical resources and transportation (Selwyn, 2011). Moreover, the use of open educational resources (OER) can drastically reduce the need for expensive textbooks, making education more accessible and affordable for students, especially in low-income areas.

However, ICT efficiency does not come without challenges. One common barrier is the digital divide, where socio-economic disparities result in unequal access to technology, making it difficult to achieve uniform ICT efficiency across regions. Another challenge is ensuring that the tools used are appropriate for the educational context in which they are applied. Schools need to carefully assess their needs and choose ICT tools that align with their educational goals to ensure that they are not underutilized or misused (Starkey, 2020). Additionally, ongoing technical support is crucial in maintaining the efficiency of ICT systems, especially when technical issues arise that teachers or students may not have the skills to address.

In conclusion, ICT efficiency in education is multifaceted, encompassing the effective use of tools, the readiness of infrastructure, the capacity of teachers, and institutional support. While the potential for ICT to improve educational outcomes is immense, achieving true efficiency requires coordinated efforts across multiple levels of the education system. Schools must invest in not only the technology itself but also the training and support needed to ensure that ICT tools are used to their full potential in enhancing the learning experience (Cox, 2003).

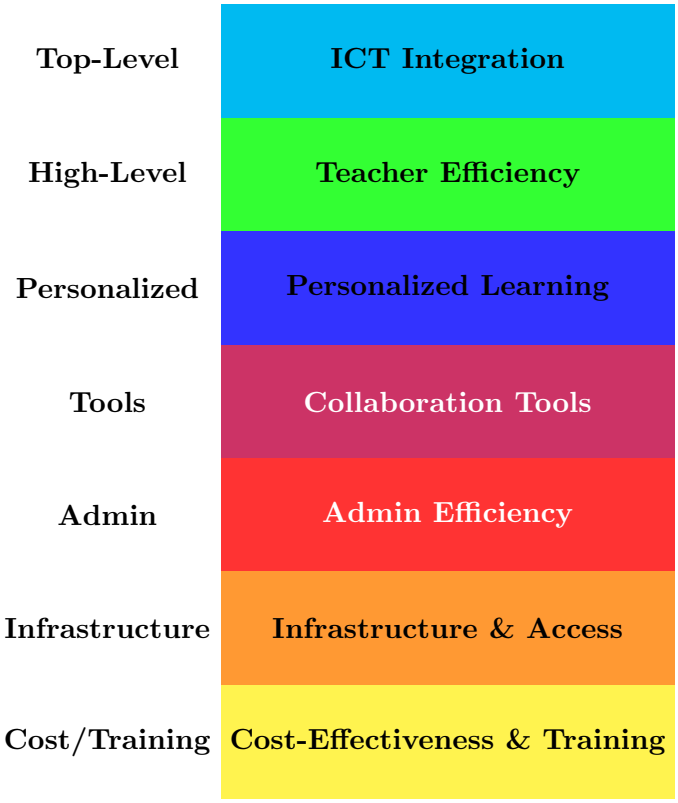

Figure 4.3: Stacked Block Diagram: Key Components of ICT Efficiency in Education

4.2 Advantages of ICT Development

The integration of Information and Communication Technology (ICT) in education brings numerous benefits, contributing to both the efficiency and the quality of the educational experience for students and teachers. These advantages span across multiple areas, including pedagogical improvements, resource availability, student engagement, and overall accessibility to education.

1. Increased Accessibility to Education: One of the most transformative advantages of ICT development is the enhanced accessibility it offers to students from diverse backgrounds. ICT tools, including e-learning platforms, online libraries, and mobile applications, enable learners to access educational materials from any location and at any time, thus promoting learning flexibility. This accessibility is especially critical in remote and underserved areas where educational resources are scarce. Studies show that students in rural areas significantly benefit from ICT integration, as it brings education closer to those who traditionally have limited access to learning resources (Unwin, 2005).

2. Improved Student Engagement: ICT tools such as digital simulations, gamified learning environments, and multimedia presentations have been shown to increase student engagement. These tools make learning more interactive and immersive, catering to different learning styles. For example, gamification in education helps motivate students by creating a more dynamic and fun learning experience. This method of instruction has been linked to improved learning outcomes, as students are more likely to retain information when they are actively engaged in the learning process (Wheeler, 2010). The use of interactive whiteboards and other digital tools also fosters collaboration among students, promoting critical thinking and peer learning (Jones, 2019).

3. Personalization of Learning Experiences: ICT development enables the creation of personalized learning pathways for students. Through adaptive learning systems, educators can design lessons that meet the specific needs and learning pace of individual students. These systems analyze data on students' performance and adjust the difficulty and content accordingly, ensuring that all students, regardless of their ability level, have the opportunity to succeed. Personalized learning not only boosts academic performance but also enhances students' self-confidence and autonomy (Picciano, 2014).

4. Enhanced Teacher Productivity and Efficiency: Teachers benefit significantly from ICT through tools that automate administrative tasks such as grading, attendance tracking, and lesson planning. Additionally, ICT facilitates continuous professional development by providing access to online resources, webinars, and communities of practice where teachers can exchange knowledge and best practices. Research suggests that teachers who effectively integrate ICT into their instruction see improvements in their ability to manage classrooms, track student progress, and design innovative lessons (McKnight et al., 2016). Moreover, ICT helps teachers save time on administrative duties, allowing them to focus more on instructional activities and student engagement (Bebell and O'Dwyer, 2010).

5. Cost-Effectiveness in Education: ICT has the potential to reduce the costs associated with traditional education models. For instance, digital textbooks and online resources replace physical textbooks, which are costly to print and distribute. Virtual learning environments (VLEs) and Massive Open Online Courses (MOOCs) provide opportunities for large-scale education delivery without the need for physical infrastructure, making education more affordable and scalable, particularly in developing regions (OECD, 2017). Additionally, the adoption of cloud-based solutions for educational management has been shown to reduce operational costs for schools by

optimizing resource use (Istance et al., 2013).

6. Bridging the Digital Divide: While ICT can widen the gap between students who have access to technology and those who don't, well-planned ICT development initiatives can help bridge this digital divide. Governments and educational institutions are increasingly investing in providing affordable ICT solutions and internet access to underserved communities. This enables students from low-income backgrounds and remote areas to access the same educational resources as their peers in urban settings. ICT's role in bridging educational inequity has been widely acknowledged as a critical element for inclusive education (Hepp and Hinostroza, 2004).

7. Encouraging Lifelong Learning: ICT development also encourages a culture of lifelong learning by providing individuals with access to education beyond the traditional classroom setting. With the proliferation of online courses and educational apps, students and professionals alike can pursue new learning opportunities at their own pace. This flexibility supports continuous education, ensuring that individuals can acquire new skills and knowledge throughout their lives, thus preparing them for the evolving demands of the workforce (Tavani, 2015).

8. Global Collaboration and Knowledge Sharing: ICT facilitates global collaboration by allowing students and educators to connect with peers and institutions across the world. Through online discussion forums, collaborative platforms, and video conferencing tools, students and teachers can engage in knowledge-sharing and collaborative projects that transcend geographic boundaries. This global interaction fosters cross-cultural understanding and helps prepare students for a globalized workforce (Kozma, 2005).

The advantages of ICT development in education are vast and far-reaching. From increased accessibility and personalized learning to improved teacher efficiency and cost-effectiveness, ICT plays a crucial role in enhancing educational outcomes. Furthermore, ICT's potential to bridge the digital divide and promote lifelong learning ensures that it remains an indispensable tool in modern education systems. By leveraging these benefits, educational institutions can create inclusive, dynamic, and efficient learning environments that prepare students for success in a technology-driven world.

Advantage	Description
Increased Accessibility	ICT allows learners to access educational materials remotely, improving educational opportunities for those in underserved or rural areas.
Improved Student Engagement	Interactive tools like simulations, gamification, and multimedia enhance student participation and retention, making learning more immersive and enjoyable.
Personalization of Learning	Adaptive learning systems tailor content to individual student needs, allowing personalized learning pathways that cater to different paces and learning styles.
Teacher Productivity	ICT improves teacher efficiency by automating administrative tasks like grading, attendance, and lesson planning. It also provides professional development resources.
Cost-Effectiveness	Digital tools like e-textbooks and online courses reduce the cost of education, replacing physical resources with more affordable and scalable digital alternatives.
Bridging the Digital Divide	Well-implemented ICT development initiatives can help bridge educational inequalities by providing affordable technology and internet access to disadvantaged groups.
Lifelong Learning	ICT promotes continuous education, allowing students and professionals to acquire new skills and knowledge throughout their lives.
Global Collaboration	ICT fosters international collaboration, enabling students and educators to engage in knowledge-sharing and teamwork through digital platforms, regardless of geographic boundaries.

Table 4.2: Key Advantages of ICT Development in Education

4.3 Research Limitations

While the findings of this study offer valuable insights into the integration of ICT in Indonesian schools, several limitations should be addressed for a comprehensive understanding. One of the key limitations is the geographical scope of the research. The study primarily focused on selected schools in urban areas, with a limited number of rural schools included. As a result, the conclusions drawn may not fully represent the diversity of ICT adoption across all regions of Indonesia, particularly in remote and underdeveloped areas. In rural settings, where access to ICT infrastructure is often sparse, the challenges of technology integration may be more severe than what was captured in this study. As highlighted by Bingimlas (2009), rural schools face unique difficulties, including inadequate infrastructure and limited access to training, which can hinder the effective use of ICT in education (Bingimlas 2009).

Another limitation is related to the teacher training and professional development provided during the study. Although teachers were introduced to basic ICT tools, the variability in their skill levels and prior experience affected the consistency of technology integration across classrooms. Research by Prestridge (2010) has shown that the success of ICT integration is heavily dependent on the quality of teacher training and their willingness to adapt to new pedagogical approaches. In this study, it was observed that some teachers struggled with incorporating ICT into their lessons, particularly those with less experience or confidence in using technology. This disparity suggests that ongoing, tailored professional development is crucial for ensuring that all teachers are adequately prepared to leverage ICT for enhancing student learning outcomes.

The study also faced constraints due to technological infrastructure, particularly in less-resourced schools. Schools with poor internet connectivity or outdated equipment were limited in their ability to implement ICT effectively. This echoes findings by Pelgrum (2001), who identified infrastructure and technical support as critical barriers to ICT adoption in education, In this context, many schools could not fully utilize the potential of ICT tools due to frequent technical issues, such as unstable internet connections, lack of hardware, and insufficient access to digital learning resources.

Additionally, the student engagement with ICT varied significantly across different schools. In some schools, students were highly motivated and actively participated in digital learning, while in others, engagement was minimal. This variation could be attributed to factors such as the novelty of ICT tools, the design of digital resources, and the extent to which teachers integrated technology into their pedagogy. According to Selwyn (2010), student motivation and the perceived relevance of ICT are key determinants of engagement in technology-mediated learning environments. In schools where students lacked prior exposure

to digital tools or where the resources were underutilized, the impact of ICT on learning outcomes was less pronounced.

The methodology employed in the study also presented certain limitations. Although the research utilized a mixed-methods approach, the quantitative surveys relied on self-reported data from teachers and students, which may have introduced bias. Participants may have either overstated or understated their use of ICT, which could skew the results. As noted by Creswell and Plano Clark (2011), self-reported data in educational research can sometimes be unreliable due to factors like social desirability bias or recall errors. Future research could address this issue by incorporating more objective measures of ICT use, such as classroom observations or digital usage analytics, to provide a more accurate picture of how technology is being implemented.

Furthermore, the duration of the study was relatively short, focusing on immediate and short-term impacts of ICT integration. This limited timeframe did not allow for an examination of the long-term effects of technology on student performance or teacher efficacy. As Voogt and Knezek (2008) point out, understanding the sustainable impact of ICT in education requires longitudinal studies that track changes over an extended period (Voogt and Knezek, 2008). Longitudinal research could provide deeper insights into how sustained ICT use influences educational outcomes, teacher practices, and student engagement over time.

Lastly, policy and institutional support were found to be uneven across the schools involved in the study. While some schools benefited from strong governmental and institutional backing, others received minimal support in terms of resources, funding, and guidance on ICT integration. The lack of a cohesive national strategy for ICT in education contributed to these disparities, as schools were left to navigate the challenges of technology integration on their own. As emphasized by Law et al. (2008), the role of policy and leadership is crucial in driving successful ICT initiatives in schools (Law et al., 2008). A more unified approach, with clear guidelines and equitable resource distribution, could help address these institutional challenges and ensure that all schools have the support they need to succeed in integrating ICT into their curricula.

In conclusion, while this study has provided valuable insights into the role of ICT in improving teaching and learning in Indonesia, it is important to recognize the limitations outlined above. Addressing these limitations in future research will not only enhance the robustness of the findings but also contribute to a more comprehensive understanding of the long-term and large-scale effects of ICT development in education.

1. Limited Resources: This block represents the challenge of having insufficient resources, such as financial or technical assets, which limits the ability to fully adopt ICT in educational settings.

2. Teacher Training Issues: The next block indicates that limited resources often lead to inadequate training for teachers. Teachers may lack the knowledge or experience to integrate ICT tools effectively in the classroom.

3. Infrastructure Disparities: This block represents the uneven distribution of infrastructure, particularly between urban and rural areas. Schools in under-resourced regions may lack access to stable internet, modern devices, or even electricity, which further hampers the integration of ICT.

4. Sample Size Constraints: This block refers to the limitations imposed by small or unrepresentative sample sizes in research studies on ICT adoption. This can make it difficult to generalize findings across broader educational contexts.

5. Contextual Variability: The final block addresses the issue of variability across different educational contexts (e.g., urban vs. rural, varying student needs, diverse pedagogical practices). This variability complicates the application of a one-size-fits-all solution for ICT integration.

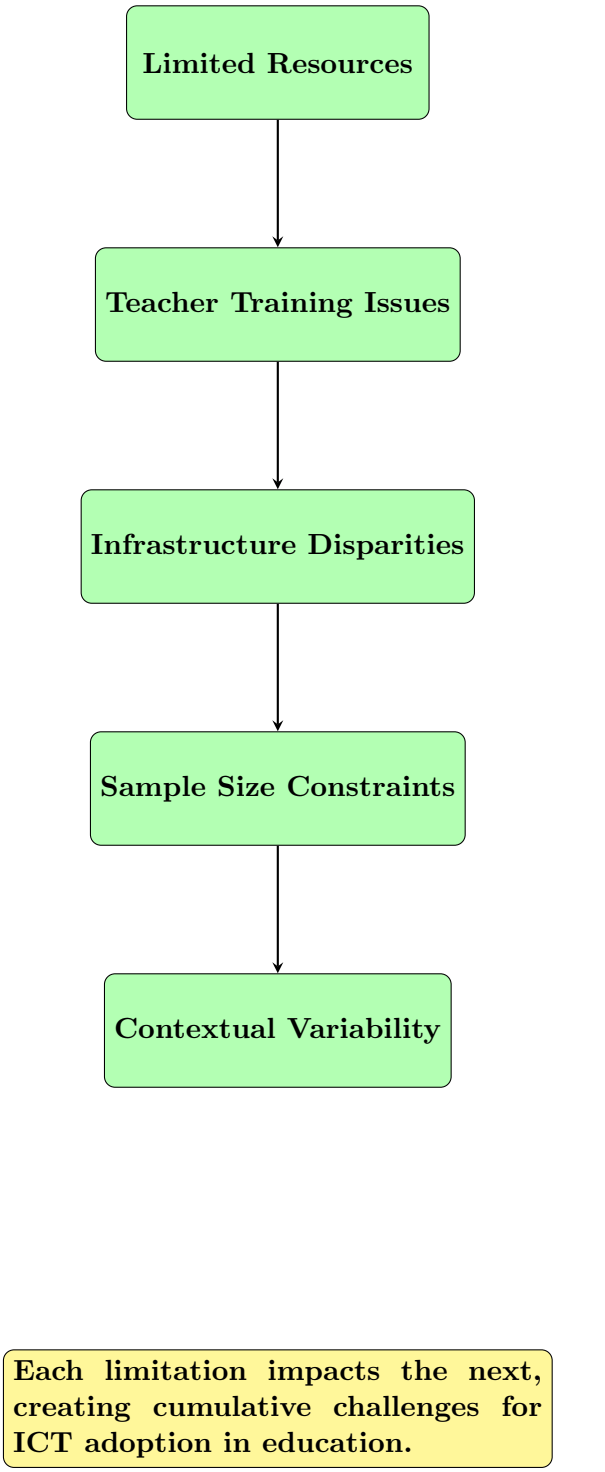

Figure 4.4: Research Limitations in ICT Development and Education

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

1. The integration of Information and Communication Technology (ICT) in the education sector has proven to be transformative, especially in countries like Indonesia, where there is a notable contrast between urban and rural educational environments. ICT serves as a powerful tool for enhancing educational outcomes by facilitating access to digital resources, promoting interactive learning, and supporting personalized teaching strategies.

2. The findings highlight that ICT, when effectively implemented, can significantly improve the quality of education by enabling diverse teaching methods and fostering greater student engagement. The use of digital tools, such as e-learning platforms, multimedia content, and collaborative software, allows educators to cater to varied learning styles and needs, leading to better academic performance and student satisfaction.

3. Persistent challenges remain, particularly in rural areas where ICT infrastructure is lacking. Issues such as unreliable internet access, outdated hardware, and insufficient technical support hinder the widespread adoption of technology in education. This digital divide exacerbates educational inequalities, limiting the potential benefits of ICT for students in remote regions.

4. Teacher training emerged as a critical factor influencing the success of ICT integration. Without adequate training, educators may struggle to utilize ICT tools effectively, impacting both teaching quality and student outcomes. Professional development programs that address both technical and pedagogical aspects of ICT are essential to ensure teachers are well-prepared to integrate technology seamlessly into their instruction.

5. The study emphasizes the importance of policy support and resource allocation. For ICT to become a fundamental component of the education system, it is crucial for

policymakers to recognize and address the unique needs of different regions. A one-size-fits-all approach will not suffice in a country as diverse as Indonesia; region-specific strategies are needed to foster inclusive and equitable ICT adoption.

6. Collaboration between educational institutions, government bodies, and the private sector is vital to sustain the momentum of ICT adoption. Public-private partnerships can play a significant role in funding infrastructure projects, providing updated technology, and developing innovative digital learning solutions tailored to local contexts.

7. While the integration of ICT holds great promise for enhancing educational quality and equity in Indonesia, achieving these benefits requires a multifaceted approach. Addressing infrastructure deficits, providing continuous teacher training, and ensuring regionally adaptable resources are key steps. By focusing on these areas, the Indonesian education system can leverage ICT to create a more inclusive, effective, and future-ready learning environment.

5.2 Recommendations

To fully harness the potential of ICT in Indonesia's education system, strategic measures must be taken to address the identified challenges. The following recommendations are aimed at enhancing ICT infrastructure, teacher preparedness, and sustainable practices to create an equitable and inclusive digital education environment:

1. Expand ICT Infrastructure in Rural Areas: The most urgent priority is bridging the digital divide between urban and rural schools. Investment should be directed towards improving internet connectivity, providing updated ICT hardware, and establishing reliable network systems. Ensuring affordable and accessible internet services will form the backbone of effective ICT use in rural schools.

2. Strengthen Teacher Training and Professional Development: Comprehensive and continuous training programs must be designed to equip teachers with both the technical and pedagogical skills necessary for ICT integration. These programs should address the needs of teachers in various contexts, including rural areas, and provide ongoing professional development to keep teachers informed of new educational technologies and methodologies.

3. Develop Adaptable and Culturally Relevant Digital Content: Digital resources should be developed with consideration for regional and cultural diversity. Collaborating with local educators to create content that reflects linguistic, cultural, and social aspects

will ensure that students across different regions benefit equally from ICT-enhanced learning.

4. Foster Public-Private Partnerships: Partnering with technology companies and non-governmental organizations can accelerate ICT development and integration. These partnerships can provide additional resources, expertise, and financial support to enhance ICT in schools and offer access to advanced tools and learning platforms.

5. Monitor and Evaluate ICT Integration: Establishing robust systems for regular assessment of ICT use in schools is vital to identify successes and areas for improvement. Tracking student performance, teacher feedback, and the effectiveness of ICT infrastructure will help inform future decisions and policies.

6. Promote Sustainable ICT Practices: ICT strategies must prioritize sustainability by using energy-efficient devices and minimizing e-waste. Additionally, financial models that ensure the long-term maintenance and upgrading of ICT resources should be established to prevent obsolescence and maintain school readiness.

7. Encourage Lifelong Learning and Digital Literacy: Integrating digital literacy programs into the school curriculum will prepare students for the demands of the modern world. Schools should encourage ongoing learning through digital platforms and provide opportunities for students and the broader community to enhance their digital skills.

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