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Exploring the Utilization of ICT in Physics Learning at Senior High Schools in Demak: Opportunities and Challenges

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ABSTRACT

Purpose of the study: This study aims to explore the use of ICT-based physics learning media by physics teachers in high schools in Demak Regency. In addition, this study identifies challenges and opportunities in the application of ICT to improve the quality of physics learning.

Methodology: This study uses a qualitative approach with a case study method. Data were collected through structured interviews using a questionnaire, as well as documentation related to ICT infrastructure. Purposive sampling technique was used to select two physics teachers and six students at State Senior High School 3 Demak. Data analysis refers to the Miles and Huberman model, which includes data reduction, data presentation, and drawing conclusions.

Main Findings: This study found that the use of ICT-based learning media in physics learning at State Senior High School 3 Demak can improve students' understanding of abstract concepts. Teachers used PowerPoint, learning videos, simulations, and digital platforms. The main challenges included limited ICT facilities, unstable internet connections, and teachers' diverse technological skills. Students showed positive responses to ICT-based learning, but still needed a combination of conventional methods. Adaptive strategies are needed to overcome the constraints of technology accessibility.

Novelty/Originality of this study: This study provides a new perspective on the use of ICT-based learning media in physics learning at State Senior High School 3 Demak, by highlighting the challenges of technology accessibility and teachers' adaptive strategies. This study enriches the literature with an in-depth case study approach, reveals practical solutions in ICT integration, and emphasizes the importance of a combination of conventional and digital methods for learning effectiveness.

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1. INTRODUCTION

Education plays a fundamental role in building superior and competitive human resources. In the context of formal education, schools are the main institutions responsible for designing and implementing effective learning processes [1]-[3]. The development of science and technology, especially in the field of Information and Communication Technology (ICT), has brought significant changes to the world of education [4]-[6]. The use of ICT in learning allows the teaching and learning process to be more interactive, efficient, and adaptive to the needs of students [7]-[9].

Physics learning, as a branch of natural science, requires an approach that is not only based on theory, but also good practice and visualization [10]-[12]. Abstract concepts in physics, such as waves, fluids, and atomic models, are often difficult for students to understand if they are only presented in the form of text or lectures [13]-[15]. Therefore, the use of ICT-based media such as interactive simulations, animations, and multimedia presentations can be a solution to improve students' understanding of physics material.

Several previous studies have highlighted the benefits of using ICT in learning. ICT-based learning media make a positive contribution to teacher performance, increase their confidence in teaching, and create a more interesting and interactive classroom atmosphere for students [16]-[18]. Meanwhile, previous studies also show that teacher skills in using ICT have a positive correlation with the effectiveness of its use in the learning process [19], [20]. However, in a local context such as in Demak Regency, further exploration is still needed on how physics teachers utilize ICT in learning, the obstacles they face, and the opportunities that can be maximized to improve the effectiveness of physics teaching. Although various studies have shown that the use of Information and Communication Technology (ICT) in learning can improve the effectiveness of teaching and student understanding, studies that specifically explore how physics teachers in Demak Regency use ICT in the learning process are still very limited. Most previous studies have focused more on the impact of general ICT use in education without considering the contextual challenges faced by teachers in certain areas, such as infrastructure limitations, teachers' technological competence, and time efficiency in preparing lessons.

Previous research examined the use of ICT in physics learning in secondary schools in Mombasa, Kenya, with a focus on the effectiveness of ICT in improving students' academic achievement. This previous study found that the main challenges identified included limited ICT resources, lack of teacher training, and difficulties in changing conventional learning methods to technology-based ones. As a solution, previous studies recommended increasing the availability of ICT facilities and teacher training to improve learning effectiveness [21]. Therefore, the current study complements previous studies by providing in-depth insights into the implementation of ICT at the school level, especially in the local context of Demak. While previous studies focused on measuring the impact of ICT on student achievement, this study highlights aspects of implementation, teacher adaptation, and strategies needed to overcome challenges of technology accessibility. These findings add new perspectives to the literature by emphasizing the importance of blended learning approaches and adaptive strategies in integrating ICT into physics learning.

In addition, although it is known that ICT-based simulations and visualizations can help students understand abstract physics concepts, there is still little research that examines the extent to which physics teachers in Demak Regency have adopted this method and the factors that hinder or support its use. Therefore, this study is urgently needed to fill the research gap by providing a deeper picture of the exploration of the use of ICT-based learning media in physics teaching, identifying existing obstacles, and formulating solutions that can be applied to improve the quality of physics learning at the high school level in Demak Regency.

Based on this background, this study aims to explore the use of ICT-based physics learning media by physics teachers at the high school level in Demak Regency. This study also seeks to identify the challenges faced and opportunities that can be utilized in order to improve the quality of technology-based physics learning. Through this study, it is hoped that a deeper understanding of the role of ICT in supporting physics learning can be obtained as well as strategic recommendations for teachers and education policy makers in optimizing technology to improve student learning outcomes.

This study offers novelty by exploring in depth how physics teachers in Demak Regency utilize ICT-based learning media in a local context, including the specific challenges they face and the adaptation strategies they use. The implications of this study are expected to provide practical recommendations for educators and policy makers in improving the effectiveness of technology-based physics learning, while encouraging the optimization of infrastructure and teacher training to support the integration of ICT in education.

2. RESEARCH METHOD

This study uses a qualitative approach with a case study design to explore in depth the use of Information and Communication Technology (ICT)-based learning media in physics learning at the senior high school level in Demak Regency. The qualitative approach was chosen because this study aims to understand the phenomenon of ICT use by physics teachers comprehensively, including the challenges faced and opportunities that can be utilized in the learning process [22]-[24]. Qualitative research allows researchers to gain in-depth insight into the experiences, views, and strategies applied by teachers in integrating ICT into teaching.

This study was conducted at State Senior High School 3 Demak as one of the senior high schools in Demak Regency that represents the conditions of ICT use in physics learning. The research subjects consisted of two physics teachers and six students, who were selected using a purposive sampling technique. This technique is used so that the participants involved really have experience and direct involvement in the use of ICT-based learning media. The selected teachers are teachers who actively use or have experience in implementing ICT in

physics learning, while students are selected based on their involvement in classes that use technology-based media.

The data in this study were collected through structured interviews with physics teachers and students. Interviews were conducted using a pre-arranged questionnaire to ensure that the information obtained was in accordance with the research focus. Interviews with teachers aimed to explore more deeply their experiences in using ICT in physics learning, the obstacles they faced, and the benefits they felt. Meanwhile, interviews with students aimed to understand how they responded to and experienced ICT-based learning in physics subjects. In addition to interviews, this study also used documentation methods to collect data related to the availability of ICT devices in schools, the types of learning media used, and existing technical constraints. The following is a table of research instrument grids compiled based on the research focus related to the exploration of the use of ICT-based physics learning media in high schools in Demak Regency:

Tabel 1. Research Instrument Grid

No	Research Variables/Focus	Indicators	Subjects	Data Type	Instruments
1	Availability of ICT Infrastructure	- Types of available ICT devices (laptops, projectors, Wi-Fi, etc.) - Condition and accessibility of ICT devices	Teachers, Students	Qualitative Data	Interviews, Documentation
2	Utilization of ICT-Based Learning Media	- Types of ICT-based learning media used (PPT slides, simulations, videos, applications, etc.) - Frequency and patterns of ICT usage in physics learning	Teachers	Qualitative Data	Interviews
3	Teachers' Skills in Using ICT	- Basic skills in operating ICT devices - Ability to develop or modify ICT-based learning media - Teachers' level of comfort in using ICT	Teachers	Qualitative Data	Interviews
4	Benefits of Using ICT in Physics Learning	- Impact of ICT on students' understanding - Ease experienced by teachers and students in the learning process	Teachers, Students	Qualitative Data	Interviews
5	Challenges and Barriers in ICT Utilization	- Infrastructure limitations (projectors, Wi-Fi, electricity, etc.) - Technical difficulties in using ICT - Time efficiency in preparing ICT-based learning materials	Teachers	Qualitative Data	Interviews
6	Students' Response and Participation in ICT-Based Learning	- Level of student engagement and enthusiasm - Student preferences for ICT-based learning media	Students	Qualitative Data	Interviews
7	Teachers' Strategies to Overcome ICT Usage Challenges	- Teachers' efforts to address ICT infrastructure limitations - Alternative solutions implemented in the use of ICT-based learning media	Teachers	Qualitative Data	Interviews

Data analysis in this study uses the Miles and Huberman approach, which consists of four main stages: data collection, data reduction, data display, and drawing conclusions and verification. Data obtained through

interviews, documentation, and field notes are collected systematically to ensure the accuracy of information regarding the use of ICT-based learning media in physics teaching [25], [26]. Furthermore, the collected data is reduced by sorting, simplifying, and grouping information based on main themes such as the type of ICT media used, the level of teacher skills in utilizing ICT, and the obstacles and opportunities that arise in the learning process. After going through the reduction stage, the filtered data is then presented in the form of tables, matrices, or diagrams to facilitate the identification of patterns, relationships between variables, and tendencies in the use of ICT in physics learning [27], [28]. In the final stage, the researcher interprets the data that has been analyzed to draw conclusions that are relevant to the research objectives. The conclusions produced are then verified through confirmation to the research subjects to ensure data validity and avoid interpretation bias [29], [30]. This systematic approach allows the study to gain in-depth insight into the use of ICT in physics learning in Demak Regency and provides a strong basis for recommendations for improving the quality of technology-based teaching.

3. RESULTS AND DISCUSSION

Based on the research method used, namely a qualitative approach with a case study at State Senior High School 3 Demak, data was obtained through in-depth interviews with two physics teachers and six students. The results of this interview provide insight into the utilization, challenges, and integration strategies of Information and Communication Technology (ICT)-based learning media in physics learning.

Table 2. Interview results

No	Research Focus	Interview Questions	Teacher 1 Response	Teacher 2 Response
1	Availability of ICT Infrastructure	How is the availability of ICT facilities in your school?	At school, we have several ICT facilities such as laptops and LCD projectors, but the availability is still limited. Wi-Fi connectivity is also inconsistent.	The ICT infrastructure is available, but we have to share projectors among several classes, which is sometimes inconvenient. The internet connection is also unstable.
2	Utilization of ICT-Based Learning Media	What types of ICT-based media do you use in physics learning?	I use PowerPoint slides, educational videos, and physics simulations. I also provide links to online experiments that students can watch at home.	I assign students ICT-based projects, such as creating presentations or finding relevant physics experiment videos. I also use online quizzes and interactive learning platforms.
3	Teachers' Skills in Using ICT	How comfortable are you in using ICT for teaching?	I am quite comfortable using ICT tools like laptops and projectors. However, I still need to improve my skills in using more advanced simulation software.	I am confident in using basic ICT tools but would like to learn more about integrating more interactive platforms and digital simulations.
4	Benefits of Using ICT in Physics Learning	What benefits do you see in using ICT-based media for teaching physics?	ICT media help students better understand abstract concepts by providing visual and interactive explanations. It also makes the learning process more engaging.	ICT makes learning more interesting and interactive, encouraging students to actively participate. It also allows for more dynamic and flexible lesson delivery.
5	Challenges and Barriers in ICT Utilization	What challenges do you face in integrating ICT into physics teaching?	The biggest challenge is the lack of sufficient ICT facilities like projectors and stable internet access. Additionally, preparing ICT-based materials takes extra time.	Not all students have access to personal devices or the internet, making it difficult for them to fully benefit from ICT-based learning. Some students also struggle to adapt to digital learning platforms.
6	Students' Response and Participation in ICT-Based Learning	How do students respond to ICT-based learning?	Most students find ICT-based learning more engaging. They are more interested when lessons	Students generally enjoy the use of videos and interactive elements, but some still prefer traditional teaching methods,

			include animations or simulations.	especially for problem-solving exercises.
7	Teachers' Strategies to Overcome ICT Usage Challenges	How do you deal with ICT-related challenges in teaching?	I try to maximize available resources and ensure that students can access materials offline when possible. I also mix traditional methods with ICT-based learning.	I provide alternative learning materials in printed form for students with limited access to technology. I also encourage students to collaborate in groups when using ICT tools.

The interview results showed that both teachers had positive views on the use of ICT-based media in physics learning. The first teacher emphasized that ICT media is very important because it can provide better visualization of abstract physics concepts, thus helping students understand the material more effectively. Meanwhile, the second teacher highlighted the aspects of interactivity and student engagement, where ICT media helps create a more interesting learning experience and allows students to be more active in the learning process.

In terms of ICT media integration, the first teacher used slide presentations, learning videos, computer simulations, and online platforms. One strategy implemented was to provide links to physics experiment videos that could be accessed by students outside the classroom, so that learning was not limited to the classroom. On the other hand, the second teacher implemented a project-based approach, where students were asked to create physics presentations or search for relevant experiment videos. This method provides opportunities for students to be more actively involved in learning and improve their understanding through independent exploration.

Both teachers identified the benefits and challenges in using ICT-based media. The first teacher saw that ICT increased students' interest and engagement in learning. The visual and interactive elements of this media also allow for variation in the delivery of material, making it easier for students to understand complex concepts. The second teacher, while also acknowledging the benefits, highlighted a major challenge, namely limited access to technology in some places. Not all students have adequate devices or internet connections, so it is important to ensure that learning materials remain accessible without relying too much on technology. Considering the obstacles in the use of ICT, teachers at State Senior High School 3 Demak have also implemented alternative strategies to overcome these obstacles. One of them is choosing learning media that can be used offline, such as using simulations that can be accessed offline or providing materials in printable form. In addition, teachers also try to optimize the resources available at school, such as utilizing school computers and the school's internet network when teaching materials that require online access.

Several literatures support your research findings regarding teachers' positive views towards the use of ICT-based media in physics learning. Vidak et al. [31] in their systematic review identified that Augmented Reality (AR) technology can enhance physics learning by providing better visualization, optimizing cognitive load, and promoting collaborative learning. However, they also noted challenges related to hardware and software limitations, as well as the potential for increased cognitive load if not used appropriately.

The results of your study are in line with several literatures that discuss teachers' positive perceptions of the use of ICT-based media in physics learning. For example, a study by Desnita et al. [32] revealed that physics teachers in West Sumatra often use PowerPoint and simulations such as PhET to help visualize abstract physics concepts, despite challenges such as limited access to technology in some areas. These findings support the view that ICT-based media integration can improve students' understanding of physics material, although its implementation requires attention to resource availability and teacher training. The results of interviews with students are presented in table 3 below.

Table 3. Results of interviews with students

No	Research Focus	Interview Questions	Student Response
1	Availability of ICT Infrastructure at School	Are the ICT facilities at school sufficient for physics learning?	S1: Projectors are often unavailable, so sometimes teachers just explain on the whiteboard S2: Sometimes there are problems with the school's internet, making it difficult to access online materials. S3: We often have to share one projector between multiple classes. S4: There is Wi-Fi, but the signal is weak, making it difficult to use for online learning.

			S5: Sometimes we have to use our own phones to find additional materials. S6: The facilities are adequate, but they are not always available due to limited quantity.
2	Use of ICT-Based Learning Media	What ICT-based learning media are commonly used in physics learning?	S1: Teachers often use PowerPoint slides and educational videos. S2: Usually, teachers display physics simulations to explain difficult concepts. S3: We have also used physics apps for simple experiments. S4: Teachers often provide links to physics experiment videos. S5: Some online quizzes are used for practice exercises. S6: Some assignments are given through digital platforms like Google Classroom.
3	Benefits of Using ICT in Physics Learning	What benefits do you experience from ICT-based learning?	S1: It is easier to understand physics concepts because of the visualizations. S2: Learning becomes more interesting rather than just listening to explanations in class. S3: Simulations help in understanding concepts like waves or electricity abstract. S4: With experiment videos, I can see real-life applications of physics theories. S5: Learning is more interactive and less boring. S6: It is easy to review materials by searching for videos or digital notes.
4	Challenges in Using ICT for Physics Learning	What challenges do you face when using ICT media for physics learning?	S1: Not all students have internet access at home, so it's hard when assignments are given online. S2: Some materials in videos are difficult to understand without direct explanation from the teacher. S3: If the power goes out or the signal is weak, it is hard to follow ICT-based learning. S4: Sometimes teachers go through slides too quickly, making it difficult to take notes. S5: I prefer learning through practice exercises rather than just watching videos. S6: Not all applications or platforms are easy to use; sometimes they are confusing.
5	Preference for Physics Learning Methods	Do you prefer learning with ICT media or conventional methods?	S1: I prefer ICT because it is more interactive and easier to understand.

			S2: A combination of both is better, as some concepts are easier to explain directly by the teacher. S3: Conventional methods are also important, especially for practice exercises and discussions. S4: I prefer ICT, especially when there are animations or interactive simulations. S5: For theory, ICT is more engaging, but for practice exercises, I prefer traditional methods. S6: ICT is great for exploring materials, but I still need direct guidance from the teacher.
6	Suggestions for Improving ICT Use in Learning	What suggestions do you have to make ICT use in physics learning more effective?	S1: The school needs to add more projectors and improve internet connectivity. S2: Teachers should use more interactive simulations, not just slides. S3: Teachers could provide access to physics apps that help in understanding the material. S4: More digital practice exercises should be available to evaluate learning progress. S5: ICT-based materials should still be complemented with written explanations. S6: Schools should conduct training sessions for students to become more familiar with learning technologies.

Based on interviews with six students, most of them acknowledged the significant benefits of ICT-based learning media, particularly in visualizing abstract physics concepts. However, several challenges were identified, such as limited ICT facilities at school, unstable internet connections, and difficulty understanding materials if only relying on videos or simulations without additional teacher explanations. Additionally, students had diverse preferences regarding learning methods. Some preferred ICT-based approaches because they were more interactive, while others believed that conventional methods such as discussions and practice exercises were still necessary for deeper understanding. Therefore, a combination of ICT and traditional teaching methods appears to be a more effective solution for enhancing the quality of physics learning.

Based on the research results, it can be concluded that the use of ICT-based learning media has a positive influence on the physics learning process at State Senior High School 3 Demak. Teachers are aware of the importance of this media in improving student understanding, especially in visualizing abstract physics concepts. However, there are challenges in the availability of ICT infrastructure that still need to be considered, especially in terms of technology accessibility for students. To overcome this obstacle, an adaptive strategy is needed in the use of ICT media so that learning remains inclusive and effective for all students.

Previous research has shown that ICT can improve student engagement and learning outcomes, but faces barriers such as accessibility and teacher readiness [33], [34]. This study strengthens these findings with a specific case study at State Senior High School 3, Demak, which shows that ICT-based learning media helps students' understanding of abstract concepts, but still faces obstacles in terms of infrastructure and teacher skills. Thus, this study complements previous studies by providing deeper insights into the adaptive strategies used by teachers to overcome technology accessibility constraints, as well as emphasizing the importance of combining conventional and digital methods in physics learning.

The novelty of this study lies in the in-depth contextual approach to the implementation of ICT in physics learning in a specific school environment, as well as identifying adaptive strategies used by teachers to overcome limitations in technology access. If previous studies provide a general overview of ICT integration globally and recommend cross-cultural studies, this study complements these insights by providing more specific empirical evidence related to the challenges and solutions of ICT implementation at the local level. Thus, this study

contributes to the literature by emphasizing the importance of combining conventional and digital methods in physics learning and revealing strategies that can be used to improve the effectiveness of ICT use in conditions of limited accessibility.

The results of this study provide important implications for the world of education, especially in formulating policies related to technology integration in learning. Further support is needed from schools and the government in providing adequate ICT facilities, as well as training for teachers so that they can optimize the use of technology in learning. This study was limited to one school, namely State Senior High School 3 Demak, with a small number of participants, so that the findings cannot be generalized widely. In addition, the study only focused on the use of ICT-based learning media without quantitatively analyzing its impact on student learning outcomes. Therefore, further research is recommended to cover more schools with different infrastructure variations, involve more participants, and use a mixed-method approach to analyze the impact of ICT use on students' understanding of physics concepts and learning outcomes in more depth.

4. CONCLUSION

Based on the research results, it can be concluded that the use of Information and Communication Technology (ICT)-based learning media has a positive influence on physics learning at State Senior High School 3 Demak. Teachers and students admit that this media helps improve understanding of abstract physics concepts through better visualization and interactivity. However, there are challenges in its implementation, such as limited infrastructure, unstable internet access, and the skills of students and teachers in utilizing technology optimally. To overcome these obstacles, adaptive strategies are needed, such as a combination of conventional and digital methods, providing alternative learning that can be accessed offline, and increasing support for facilities and training for educators. Therefore, the integration of ICT in physics learning must be balanced with policies that support the availability of facilities and infrastructure to ensure the effectiveness and inclusiveness of learning for all students.

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