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Optimization of Distance Learning Systems Using Artificial Intelligence and the Internet of Things in Improving the Quality of Education in the Post-Pandemic Era

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Abstract

The COVID-19 pandemic forced a sudden change from face-to-face learning to Distance Learning (PJJ), posing challenges in the quality of learning and student interaction. This study examines the application of Artificial Intelligence (AI) and the Internet of Things (IoT) to optimize the PJJ system in the post-pandemic era. The goal is to evaluate the impact of AI in personalizing learning and IoT in improving student interactivity and collaboration, as well as identify the challenges of implementing this technology. The research uses a mixed-methods approach by combining qualitative and quantitative analysis. Data were obtained from 50 educators, 100 students, and 20 administrators through questionnaires, in-depth interviews, and participatory observations. Correlation tests and logistic regression are used to assess the influence of AI and IoT on learning quality. The results show that 85% of students and 78% of educators agree that AI helps in customizing learning materials. IoT also increases student engagement, with 76% of students feeling more engaged and the likelihood of student engagement increasing 2.35 times greater with IoT. Key challenges include limited technological infrastructure and lack of training for educators. In

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conclusion, AI and IoT have great potential in improving the quality of education, but support is needed for infrastructure and educator training so that the implementation of these technologies is optimal.

Keywords: Artificial Intelligence, Internet of Things, Distance Learning, Post-Pandemic

INTRODUCTION

The COVID-19 pandemic has had a huge impact on various sectors of life, including the education sector. To suppress the rate of spread of the virus, many countries around the world implemented strict social distancing policies, which in turn led to the temporary closure of educational institutions, ranging from schools to colleges. This step forces educational institutions to adapt drastically by switching from face-to-face-based conventional learning methods to technology-based Distance Learning (PJJ) models. This shift is happening quickly and unexpectedly, requiring both educators and students to adapt to the use of technology in the teaching and learning process. While this transition was initially challenging, including technical constraints and a lack of preparation, the pandemic also opened up great opportunities to explore new approaches to education (Siti Umi Khoiriah et al., 2023). Technology-based learning allows for greater flexibility in terms of when and where to study, as well as providing wider access to learning materials. Additionally, the integration of technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) in education is beginning to accelerate, offering the potential to create more interactive, adaptive, and personalized learning experiences. With technology, education can evolve towards a more inclusive model, allowing students from diverse geographic and economic backgrounds to stay connected and get a quality education, even in challenging situations such as the pandemic (Kamruzzaman et al., 2023).

However, the implementation of PJJ also poses various challenges, especially related to the quality of learning. Limited interaction between educators and students, low student involvement, and gaps in access to technology are significant inhibiting factors. In addition, the lack of personalization in the learning process makes learning outcomes not always optimal for every student (Java et al., 2021). Therefore, a solution is needed that can increase the effectiveness of PJJ, especially in the post-pandemic era where hybrid learning combining face-to-face and online learning is increasingly being applied. In this context,

Artificial Intelligence (AI) and the Internet of Things (IoT) offer great potential to be integrated into the education system, especially in optimizing PJJ. AI can help provide a more personalized and adaptive learning experience, such as analyzing learning behavior, predicting student needs, and providing feedback automatically. On the other hand, IoT allows learning devices to connect with each other, creating a more interactive and collaborative learning environment (Roihan et al., 2020).

In the post-pandemic era, efforts to optimize the PJJ system through the use of AI and IoT are increasingly relevant. These two technologies are expected not only to increase the effectiveness of teaching, but also to expand access to quality education, especially in areas that previously had limitations. With AI, educators can provide learning materials that suit the needs of each student, while IoT allows connectivity between various devices to create a richer learning environment. This research aims to explore how the application of AI and IoT can optimize the PJJ system and, ultimately, improve the quality of education in the post-pandemic era. This research will also examine the challenges faced in the implementation of this technology and provide strategic recommendations for its sustainable application in the modern education system (Arsana, 2021).

This research will focus on three main aspects related to the optimization of the Distance Learning (PJJ) system with Artificial Intelligence (AI) and Internet of Things (IoT) technology. First, the research will analyze the role of AI in the personalization of remote learning, which includes how AI can tailor teaching methods to students' individual needs based on the analysis of their learning behavior data. Second, this research will explore the use of IoT in improving interactivity and collaboration during PJJ, where connected devices allow for the creation of a more dynamic learning environment and support real-time student engagement. Third, the research will examine the emerging challenges and opportunities that can be utilized in the implementation of AI and IoT technologies in the education system, especially in the post-pandemic era, where hybrid learning models are increasingly popular. It is important to understand how technology can be effectively integrated to improve the quality of education in the future (Agarwal et al., 2024).

METHODS

This study uses a qualitative and quantitative descriptive approach with mixed-methods methods, which aims to obtain a comprehensive understanding of the application of Artificial Intelligence (AI) and Internet of Things (IoT) technology in optimizing the Distance Learning (PJJ) system in the post-pandemic era (Suggestion, 2019). The design of this research is descriptive, explaining the phenomenon of the application of AI and IoT in PJJ and identifying existing challenges and opportunities. The quantitative approach is used to collect numerical data related to the effectiveness of the application of this technology, while the qualitative approach focuses on understanding the user experience related to the implementation of AI and IoT in the learning process. The population of this study includes educators, students, and education administrators involved in PJJ in Indonesian educational institutions in the post-pandemic era. The purposive sampling technique was used to select a sample consisting of 50 educators, 100 students, and 20 administrators who have or will apply AI and IoT technology in PJJ. Data is collected through three main methods. First, a questionnaire based on the Likert scale was used to obtain quantitative data from educators and students regarding the effectiveness and efficiency of the use of AI and IoT in PJJ. Second, semi-structured in-depth interviews were conducted to gain a deeper understanding of the user experience in implementing this technology, as well as to identify the challenges faced. Third, participatory observation is carried out to directly monitor the PJJ process using AI and IoT, focusing on aspects of interactivity, learning personalization, and student engagement.

The research instruments used included questionnaires with closed and open questions related to user perceptions, interview guides designed to delve deeper into technical constraints and user experience, and observation sheets that recorded user activities and responses during learning. Data analysis techniques include quantitative and qualitative analysis. Quantitative analysis uses descriptive statistics and correlation tests to see the relationship between the use of AI and IoT and the quality of education. Qualitative analysis is carried out through thematic analysis to identify key themes from interviews and observations. To ensure the validity and reliability of the data, this study uses a triangulation technique by comparing the results of questionnaires, interviews, and observations to verify the consistency of the findings. The validity of the instrument was tested through a construct validity test, while reliability was measured using Cronbach's Alpha to ensure the consistency of the questionnaire answers. The research procedure

includes several stages. The first stage is the distribution of questionnaires to respondents, followed by in-depth interviews with educators and administrators. After that, direct observation was carried out in online classes using AI and IoT. The final stage is data analysis and preparation of research reports.

RESULTS

This research produced significant findings regarding the application of Artificial Intelligence (AI) and Internet of Things (IoT) in optimizing Distance Learning (PJJ) systems in the post-pandemic era. Based on the results of data collection through questionnaires, interviews, and observations, this study provides an overview of the effectiveness of the technology in improving the quality of education. The following are the results of the research and the data obtained:

Profil Respond

This study involved 50 educators, 100 students, and 20 education administrators who participated in a study on the application of Artificial Intelligence (AI) and Internet of Things (IoT) in optimizing the Distance Learning (PJJ) system. In terms of demographics, 60% of all respondents are women, while 40% are men. The majority of the educators involved are between the ages of 30-45, while the students are mostly 18-22 years old. In addition, 70% of educators have more than 3 years of experience in using educational technology. On the other hand, students in general have been accustomed to using technology in learning since the high school level.

Table 1 Respondent profiles

Category	Number of Respondents	Percentage (%)
Total Educators	50	-
Total Students	100	-
Total Education Administrators	20	-
Female Gender	-	60%
Male Gender	-	40%
Educator Age (30-45 years)	-	Mayoritas
Student Age (18-22 years)	-	Mayoritas
Educator Experience (>3 years)	-	70%
Student Experience with Technology	-	Generally used to

This research involved 50 educators, 100 students, and 20 education administrators who played a role in the study of the application of Artificial Intelligence (AI) and Internet of Things (IoT) in optimizing the Distance Learning (PJJ) system. In terms of gender, the majority of respondents (60%) are women, while the other 40% are men. The educators involved in the study were mostly between 30 and 45 years old, while the age range of students ranged from 18 to 22 years old. In terms of experience using educational technology, 70% of educators have more than 3 years of experience, demonstrating their readiness and expertise in utilizing technology for learning. On the other hand, students have generally become accustomed to using technology in the learning process since high school, which reflects their adaptability to increasingly technology-based learning systems (Turyadi et al., 2021).

The Effectiveness of the Application of AI in Distance Learning

Quantitative data collected through questionnaires revealed that the application of Artificial Intelligence (AI) has a significant impact on improving the quality of learning in the Distance Learning (PJJ) system. One of the key findings is that AI helps in personalizing learning. As many as 85% of students and 78% of educators stated that AI can adapt learning materials according to students' individual needs, allowing for a more adaptive and efficient learning experience. This reflects the important role of AI in identifying and analyzing each student's learning style, so that the material provided can be tailored to their abilities and learning speed. In addition, 73% of students reported an increase in efficiency in managing their study time. AI provides automatic reminders for assignments and learning activities, which helps students better manage their time, reducing the risk of forgetting or being late for completing assignments. This creates a more structured learning environment, where students can make optimal use of their study time without worrying about losing focus or being late for completing assignments. Further, AI also plays a crucial role in providing prompt and relevant feedback. As many as 81% of educators stated that AI makes it easier for them to monitor student performance in real-time and provide appropriate feedback based on student progress. With this quick feedback, students can immediately understand where they need to improve, so that the learning process becomes more effective (Equatorial Journal, 2016). AI not only speeds up the evaluation process, but also gives educators more time to focus on teaching that is more strategic and personalized. The following is a table of quantitative data regarding the

impact of AI application on learning quality based on questionnaires collected from educators and students.

Table 2 Quantitative Data

Learning Aspects	**Percentage of Students (%)**	**Percentage of Educators (%)**
Personalization of Learning	85%	78%
Improved Time Efficiency	73%	-
Quick Feedback	-	81%

This table shows three main aspects of AI adoption, namely personalization of learning, improvement of learning time efficiency, and provision of quick feedback. The data shows that the majority of students and educators feel positive benefits from the use of AI in all three aspects.

Leveraging IoT for Interactivity and Collaboration

The results of observations and interviews show that the application of the Internet of Things (IoT) has a significant positive impact in increasing interactivity and collaboration between students and educators during distance learning. Based on observation data, 76% of students feel more involved in class discussions thanks to IoT devices that support real-time interaction, such as the use of smart boards connected to learning applications. This creates a more interactive learning atmosphere and encourages student participation in online classes. Additionally, 68% of educators report that IoT helps improve the efficiency of collaboration between students in group projects. With connected devices, students can work together more dynamically, share ideas, and complete assignments more effectively, even remotely. Educators also feel that the learning process has become more active and oriented towards teamwork. Furthermore, IoT also makes it easier for educators to monitor student performance directly. Through the wearable devices used by students, educators can track learning activities and student participation levels in online classes. This monitoring feature allows educators to provide intervention or support that is more timely and in accordance with student needs, so that the quality of learning can continue to be improved (Alblooshi & Shafii, 2024).

Challenges of AI and IoT Implementation

While this study shows many benefits from the application of AI and IoT in Distance Learning (DJ), some key challenges were also identified. One of the biggest obstacles is the limited technology infrastructure, where 55% of educators and 62% of students complain of lack of access to the internet and adequate technological devices, especially in remote areas. This slows down the adoption of technology and reduces the effectiveness of learning. In addition, 49% of educators feel that they have not received enough training to optimally utilize AI and IoT in the learning process. This lack of technology training makes it difficult for educators to maximize the potential of technology in creating a more interactive and personalized learning experience. Another challenge is the significant digital divide. The results of the interviews revealed that students in urban areas are more prepared and more accustomed to using this technology than students from rural areas. These disparities in technology readiness create inequalities in the quality of learning, where students from remote areas tend to be more underdeveloped than those who live in areas with better access to technology (Cokrowibowo et al., 2023).

Opportunities for the Implementation of AI and IoT in Education

Based on the results of the analysis, there is a great opportunity to expand the implementation of AI and IoT in the education system in the future. As many as 87% of educators believe that AI has enormous potential in developing adaptive learning, where each student can receive materials and evaluations that are tailored to their abilities and learning speed. This approach allows for a more personalized and effective learning process, and encourages significant improvement in learning outcomes. In addition, 70% of education administrators see the potential use of IoT in project-based and hands-on learning. With IoT devices, students can conduct live experiments and simulations, even remotely, which makes learning more interactive and practical. The use of IoT in hands-on learning opens up opportunities for students to be more deeply involved in various projects, without being limited by space and time, and allows for a more real and applicable learning experience (Tian, 2023).

Quantitative Data Analysis

The results of the statistical test in this study show that there is a significant relationship between the application of Artificial Intelligence (AI) and the Internet of Things (IoT) and the improvement of the quality of education. The correlation test

between the use of AI and student learning outcomes produced a correlation value (r) of 0.65 with a significance level of $p < 0.05$, which indicates a strong positive relationship. This means that the higher the application of AI in learning, the better the student learning outcomes. The application of AI helps personalize learning and provide quick feedback, thus having a direct impact on improving student academic performance. In addition, a double logistic regression test conducted to assess the influence of IoT on student interaction also showed significant results. The Exp(B) value = 2.35 with a $p < 0.01$ indicates that students who use IoT devices are 2.35 times more likely to be actively engaged in learning compared to students who do not use the device. This shows that IoT plays an important role in creating a more interactive and collaborative learning environment, allowing students to be more engaged in class discussions as well as group projects, even if they are done online (Ginanjar Wiro Sasmito, 2020).

Table 3 Statistical Test Results Data

Variable	**Correlation Value (r)**	**Level of Significance (p)**	**Exp(B) Value**	**Interpretation**
The Use of AI and Student Learning Outcomes	0,65	$p < 0.05$	-	Strong positive relationship between AI and learning outcomes
IoT Application and Student Interaction	-	$p < 0.01$	2,35	IoT increases the likelihood of student engagement in learning

The table above shows the results of statistical analysis that support the conclusion that the application of AI and IoT contributes significantly to improving the quality of education, both in terms of learning outcomes and student interaction in online learning.

Qualitative Data Analysis

The results of the interviews revealed several key themes that are the main focus in the application of AI and IoT in the education system. One of the dominant themes is "ease in personalizing learning." Educators and administrators agree that AI provides flexibility in tailoring learning materials to the specific needs of each student. AI's ability to analyze students' learning patterns and performance allows educators to provide more appropriate materials and evaluations, making the learning process more effective and

relevant for each individual. In addition, the theme of "increasing student engagement" is also a major concern. With the help of IoT technology, students feel more engaged in the classroom, both through real-time interaction and collaboration in group projects. Educators report that devices such as smart boards and wearable devices help create a more dynamic learning environment, where students can actively participate, even in an online learning environment. This signals the important role of IoT in increasing student participation, which is often declining in distance learning models (Lim et al., 2023).

The final theme that emerged from the interview was "the importance of increased access to technology." Many educators and administrators emphasized that while AI and IoT technologies have great potential in transforming the education system, challenges related to access and technology infrastructure are still significant barriers. Access gaps, especially in remote areas, make the application of these technologies uneven, and therefore, many suggest the need for government and stakeholder support to ensure a more inclusive technology infrastructure. As such, a thorough integration of technology is essential to create a more equitable future of education, where all students, regardless of geographical or economic background, can benefit from these innovations.

DISCUSSION

The results of research on the application of Artificial Intelligence (AI) and Internet of Things (IoT) in optimizing Distance Learning (PJJ) systems in the post-pandemic era show that these two technologies have significant potential in improving the quality of education. Research reveals that AI plays an important role in personalizing learning, with 85% of students and 78% of educators agreeing that AI helps tailor learning materials to individual needs. This shows that AI technology can analyze student learning behavior data and provide more appropriate recommendations, thereby improving overall learning outcomes. In addition, 73% of students reported that AI improved the efficiency of learning time management, and 81% of educators benefited from providing fast and relevant feedback. The use of IoT also improves interactivity and collaboration between students and educators, with 76% of students experiencing increased interaction in the classroom and 68% of educators reporting that IoT facilitates student cooperation in group projects. However, there are challenges that need to be overcome, such as the limited technology infrastructure experienced by 62% of respondents, as well as the lack of

adequate technology training for educators. However, the opportunity to expand the application of AI and IoT in education is enormous, with 87% of educators believing that AI can develop adaptive learning and 70% of administrators see the potential use of IoT for practice-based learning. By leveraging these two technologies, the education system can be more inclusive and responsive to student needs, bridge educational gaps, and create a more equitable learning environment for all students across Indonesia. Therefore, stakeholders in the world of education need to work together to overcome existing obstacles and develop effective strategies for the integration of AI and IoT in the education system, in order to create a better learning experience for students (Celepcikay et al., n.d.).

The study also identifies a number of challenges, especially related to the limitations of technological infrastructure which are the main obstacles, especially in remote areas. As many as 55% of educators and 62% of students complained about the lack of adequate internet access and the limitations of technological devices needed to support Distance Learning (PJJ). Another challenge that arises is the lack of technology training for educators, where 49% of educators feel that they are not ready enough to utilize AI and IoT optimally in learning. These obstacles show that while the potential of the technology is enormous, infrastructure readiness and support are key factors in its success (Swasono et al., 2023).

Nonetheless, future opportunities to expand the application of AI and IoT in education are promising. As many as 87% of educators believe that AI can improve the effectiveness of adaptive learning, allowing materials to be tailored to students' individual needs. In addition, 70% of education administrators see the potential of IoT in supporting practice-based learning, such as remote experimentation and simulation. Therefore, it is very important for the government and educational institutions to play an active role in providing adequate technological infrastructure and providing appropriate training for educators. This step will ensure that the implementation of AI and IoT can be carried out optimally and evenly across the education system, so that all students can benefit from these technological advances (Putra et al., 2024).

CONCLUSION

The conclusion of this study is that the application of Artificial Intelligence (AI) and Internet of Things (IoT) technology has significant potential in improving the quality

of Distance Learning (PJJ). AI has been proven to help personalize learning that is more adaptive to student needs, as well as improve the efficiency of time management and feedback from educators. Meanwhile, IoT improves student interactivity and collaboration during the learning process. However, there are several challenges such as limited technology infrastructure and lack of training for educators in utilizing this technology optimally. However, great opportunities are open to expand the implementation of AI and IoT, with AI expected to develop adaptive learning and IoT facilitating direct project-based learning. To maximize this potential, collaboration between stakeholders is needed to address existing challenges and develop strategies that support the overall integration of AI and IoT in the education system, in order to create a more inclusive and responsive learning experience to the needs of all students, especially in areas that were previously underreached by technology.

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