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Smart Education in the AI Era: Trends and Innovations in Personalized Learning in Pesantren

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Abstract:
This study examines trends and innovations in personalized learning based on artificial intelligence (AI) in the context of Islamic education in Islamic boarding schools (pesantren). The primary objective of this study is to identify the impact of AI technology implementation on the teaching and learning process, teacher work efficiency, and infrastructure challenges faced in implementing smart education. Using a descriptive qualitative approach, data was collected through interviews with asatidz (Islamic teachers), Islamic boarding school principals, and other stakeholders. The study results indicate that the use of AI can adapt learning materials to the needs and abilities of each student, thereby increasing engagement and motivation to learn. Furthermore, teachers experienced increased work efficiency through automated systems for assessing and monitoring student progress. However, the implementation of this technology remains hampered by infrastructure constraints such as a lack of digital devices, unequal internet access, and minimal training for educators. This study concludes that AI has significant potential to revolutionize learning in Islamic boarding schools, provided it is supported by technological readiness and increased human resource capacity. The implications of this study highlight the need for strategic policies to accelerate the equitable and sustainable digitalization of Islamic education in the AI era.

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INTRODUCTION

The development of artificial intelligence (AI) technology has brought significant changes to various aspects of life, including the education sector. One of the main trends in education today is smart education, which uses AI to create more adaptive and data-driven learning experiences(Al Shloul et al., 2024; Alsubaie, 2022; Guan et al., 2020). AI enables more personalized learning by analyzing each individual's needs, abilities, and learning styles in real time(Ezzaim et al., 2024). Around the world, schools and universities have begun adopting AI-based systems to support more effective and

efficient learning(Manshur et al., 2023). However, implementing this technology in Islamic boarding schools (pesantren) still faces various challenges, including infrastructure readiness, teacher recruitment, and the alignment of technology with Islamic educational values.

In Islamic boarding schools (pesantren), traditional learning methods remain the primary approach, with the halaqah (religious gathering), sorogan (religious study group), and bandongan (religious group) systems relying on direct interaction between the kiai (Islamic scholars) and students (santri). While this approach has proven effective in preserving Islamic scholarly traditions, the emergence of new challenges in the digital era demands innovation in learning strategies(Mundiri et al., 2021; Tafat et al., 2024). Students today face challenges in accessing a wider range of learning resources, adapting learning methods to individual needs, and navigating the complexities of the modern workplace that require new skills(Lestari & Nabila, 2024). Some Islamic boarding schools (pesantren) have begun adopting digital technology in their learning, such as the use of interactive Quranic applications and Islamic-based e-learning platforms(Kusumawardani et al., 2022). However, the use of AI in personalized learning has yet to be widely studied and implemented in Islamic boarding schools.

Previous research has shown that the application of AI in education can increase student engagement and learning effectiveness. For example, research by Sutrisno et al., (2023) found that AI in education can adapt the curriculum based on analysis of student learning data, thereby improving their understanding of the material. Furthermore, research by Lin et al., (2024) shows that AI in Islamic education can be used to enhance the Quran learning experience with a speech recognition system that assists students with Tajweed pronunciation. However, studies on how AI can be integrated into Islamic boarding school education systems are still very limited. Therefore, this study aims to fill this gap by exploring AI trends and innovations in personalized learning in Islamic boarding schools as a form of modernizing Islamic education.

This research aims to analyze how AI can be applied in Islamic boarding school education systems to enhance personalized learning. Several aspects will be examined, including how AI can adapt material to students' needs, improve administrative efficiency in the learning process, and support interactions between students and teachers. The main argument in this research is that the application of AI in Islamic boarding schools will not only improve learning effectiveness but also help them adapt to current demands without abandoning Islamic educational values. Therefore, this research is expected to provide new insights into how AI-based smart education can be effectively implemented in Islamic boarding schools and open up opportunities for innovation in Islamic education in the digital era.

RESEARCH METHOD

This research uses a qualitative method with a case study approach to analyze the implementation of artificial intelligence (AI)-based personalized learning in Islamic boarding schools (pesantren). The unit of analysis includes Islamic boarding schools in

Indonesia that have implemented or are developing AI technology in their learning systems. The main focus of this research is to explore how AI is used to adapt learning materials to the needs of students, improve the effectiveness of interactions between teachers and students, and optimize educational administration. Furthermore, this study also aims to identify opportunities and challenges in implementing smart education in Islamic boarding schools.

The information sources for this study involved 14 informants selected based on their relevant roles in the implementation of AI in Pesantren Sirojul Arifin. These informants included Islamic boarding school leaders, such as caretakers or pesantren principals, who provided insights into the strategic policies and vision of the Islamic boarding school in adopting AI. Furthermore, the study involved teachers or ustaz (Islamic teachers) responsible for implementing AI in the learning process, as well as students (santri) who use the technology in their learning activities. System operators or the Islamic boarding school's IT team were also interviewed to understand the technical aspects of managing AI in education. Parents of students were also included to provide perspectives on the impact of AI on their children's academic development and character.

Table 1. Research informants

Informant	Education				Gender		Amount
	MA	S1	S2	S3	L	P	
Islamic Boarding School Leader				1	1		1
Ustad/Ustadzah		1	2		2	1	3
Students	4				2	2	4
IT department manager	1	2			2	1	3
Guardian of the Students		3			2	1	3
Total	5	6	2	1	9	5	14

The data collection method in this study employed three main techniques: in-depth interviews, observation, and documentation. Interviews were conducted with Islamic boarding school leaders, teachers, students, and IT operators to explore the experiences, challenges, and benefits of implementing AI in learning. Direct observations were made of the use of AI in the teaching and learning process, including how AI adapts learning materials to the students' needs. Additionally, documentation in the form of institutional policies, technology use reports, and students' academic records were analyzed as secondary data to strengthen the research findings.

Data analysis was conducted using the (Miles et al., 2014) model, which consists of three main stages. First, data reduction was carried out by filtering important information from interviews, observations, and documents. Second, data was presented in thematic or tabular form to facilitate interpretation and identify key patterns in AI implementation in Islamic boarding schools. Third, data verification was carried out by drawing conclusions based on the findings and ensuring the accuracy of the results through source triangulation and member checking. This process aims to produce valid and in-depth conclusions regarding the application of AI in smart

education for Islamic boarding schools, as well as identifying optimal strategies for utilizing AI to enhance personalized learning in Islamic educational environments.

RESULTS AND DISCUSSION

Result

AI in Personalized Learning

The application of Artificial Intelligence (AI) in personalized learning at pesantren has had a positive impact, particularly in tailoring learning materials to each student's individual needs. This system utilizes student performance data such as grades, assignment time, and interactions within the learning platform to develop appropriate materials. One teacher stated, "After implementing the AI system, we can identify which students are slow to grasp the lesson and which need more challenges."

head of the Islamic boarding school reported that students appeared more engaged in the learning process because the content they encountered was tailored to their individual interests and abilities. Observations showed an increase in student enthusiasm for learning and increased student independence. One homeroom teacher stated, "Students who were usually passive in class are now starting to actively ask questions because they feel the lessons are tailored to their needs." The principal also added that this approach has helped improve students' average grades in several core subjects. AI provides personalized recommendations that help students review the material independently and progressively. In an interview, he said, "The students feel valued because they don't all have to learn the same thing at the same time. This really helps us build students' confidence."

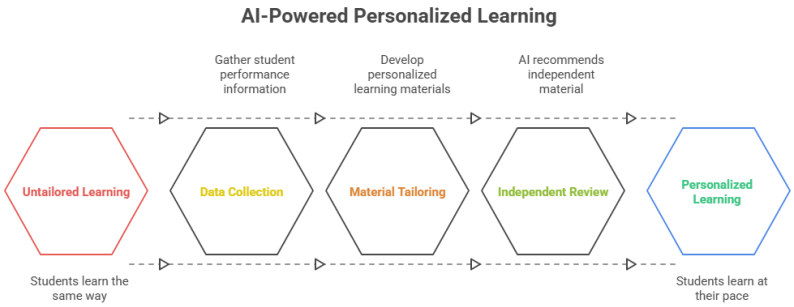

Figure 1. Personalized Learning

Figure 1, above shows the transformation of learning from a uniform method to personalized learning through the use of artificial intelligence (AI). This process begins with non-customized learning, where all students learn in the same way, then continues with the collection of student performance data (data collection), the development of personalized materials (material customization), and the provision of independent material recommendations by AI (independent review). Finally, students reach the personalized learning stage, allowing them to learn at their own pace and according to their own needs. This approach reflects more adaptive, effective, and learner-centered learning.

Teacher Efficiency

AI has also helped improve teacher efficiency in Islamic schools. With features like automatic correction, student progress tracking, and grade report generation, teachers' administrative burdens have become significantly lighter. One math teacher said, "It used to take me two nights to correct a ninth-grade assignment, but now it only takes an hour because everything is processed by the system." With more efficient time, teachers can now focus more on designing engaging and interactive learning activities. This also results in higher quality learning because teachers can adapt their teaching strategies based on the data provided by the system. Another teacher said, "From the AI reports, I know who needs more guidance, so I can create more targeted study groups."

Furthermore, the AI system also facilitates more measurable reflection on learning. Teachers can monitor the effectiveness of their methods and make adjustments in real time. One Islamic Religious Education teacher said, "We no longer rely on guesswork. Now everything is based on data which material is most difficult, which sections need to be reviewed, and which students are still behind."

Infrastructure Challenges

On the other hand, implementing AI in Islamic schools still faces significant challenges, particularly in terms of infrastructure. Many schools, particularly in rural areas, lack adequate technological devices or stable internet access. One principal said, "Sometimes we have to share one computer with five teachers because we don't have sufficient facilities." Teachers enthusiastic about using AI also complained about a lack of training and technical support. Some felt they hadn't yet mastered this new technology. A social studies teacher said, "I'd love to implement such a system, but honestly, we're still confused about how to operate it. We haven't received adequate training from the department."

Even Islamic schools that have attempted limited AI adoption still rely on external assistance for funding and equipment. An administrative staff member said, "We can only buy equipment if we have BOS funds or assistance from third parties. Otherwise, we're forced to use the old methods." This demonstrates that there are still serious gaps that need to be bridged for digital transformation to occur equitably.

Table 2. Challenges in Implementing AI in Islamic Schools

Challenge Aspect	Field Evidence
Limited Infrastructure	“One computer is shared by five teachers due to insufficient facilities.”
Internet Access	“Not all classrooms have stable internet access, especially in rural areas.”
Lack of Training	“We’re still confused about how to operate the system, no formal training yet.”
Dependence on External Funding	“We can only purchase equipment if BOS funds or third-party support is available.”

The table 2, above highlights key challenges in implementing AI within Islamic schools, particularly related to infrastructure, human resource capacity, and funding. The lack of devices and internet access hampers readiness, while the absence of proper training leaves teachers struggling to adopt AI tools effectively. In many cases, schools rely heavily on external support for technological upgrades, reflecting a digital divide that must be addressed through strategic policy and investment to ensure equitable digital transformation in education.

DISCUSSION

The application of AI in personalized learning demonstrates that this technology plays a crucial role in optimizing student learning potential in pesantren. AI systems are capable of mapping student abilities and automatically presenting appropriate material, thereby minimizing gaps in understanding in the classroom(Jusubaidi et al., 2024; Listrianti, 2020). This aligns with research by Sofiah Sinaga et al., (2021), which states that AI can improve curriculum adaptation to individual learning needs. Furthermore, AI provides real-time feedback, helping teachers more accurately monitor student progress(Damayanti, 2023; Lucia Maduningtias, 2022). In the pesantren context, AI-based learning can also be tailored to incorporate Islamic values, making it a tool that supports both character and academic education.

AI significantly improves teacher work efficiency by automating various previously time-consuming technical tasks. According to a study by Rahmawati et al., (2024), AI not only supports learning but also reduces teachers' workload, allowing them to focus more on more valuable pedagogical aspects. In the pesantren context, this is crucial because teachers are not only responsible for transferring knowledge but also for fostering moral and spiritual development(Fahruddin, 2020). With the reduced administrative burden, teachers have more room to guide students holistically, in line with the comprehensive mission of Islamic education.

Infrastructure challenges are a limiting factor in implementing smart education in pesantren environments. AI requires a stable support system, from internet connections and hardware to human resource training. As Hasanah et al., (2024) noted, without adequate infrastructure support, AI technology cannot be implemented equitably and sustainably. In the pesantren context, this issue must be a primary concern for the government and Islamic education administrators, ensuring that digital transformation is not merely a discourse but can be realized in an inclusive and equitable manner(Alkaeed et al., 2023; Rico-Juan et al., 2024). Teacher training programs and investment in reliable devices and internet connections are strategic steps to expand the implementation of AI in Islamic schools, including those in remote areas.

CONCLUSION

The application of Artificial Intelligence (AI)-based Smart Education in the Pesantren context shows a positive trend towards personalized learning innovation, increased teacher work efficiency, and infrastructure challenges that still need to be

addressed. Research findings reveal that AI can adapt learning materials to individual student needs, increase student engagement and motivation, and ease teachers' administrative burdens through the automation of routine tasks. However, the implementation of this technology still faces significant obstacles such as limited equipment and training, especially in pesantren. Overall, AI innovation in Islamic education has a significant transformational impact, both on the quality of the teaching and learning process and the efficiency of educational management, as long as it is accompanied by adequate infrastructure and training support.

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