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Integration of Artificial Intelligence in Learning at Madrasah Ibtidaiyah to Improve Students' Competence and Digital Literacy

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Abstract
The integration of Artificial Intelligence in education has become a strategic innovation in responding to the demands of the digital era, particularly in enhancing students' competencies and digital literacy. This study aims to analyze the implementation of Artificial Intelligence in learning at Madrasah Ibtidaiyah and its impact on improving students' competencies and digital literacy. This research employs a qualitative approach with a descriptive design. Data were collected through in-depth interviews, observations, and documentation, and analyzed using an interactive model consisting of data reduction, data display, and conclusion drawing. The findings reveal that the integration of Artificial Intelligence significantly improves students' digital competencies, including their ability to use technology, access and evaluate information, and develop critical thinking skills. Furthermore, AI-based learning creates a more interactive, adaptive, and personalized learning environment, which enhances students' motivation and engagement. However, the implementation still faces several challenges, such as limited technological infrastructure, varying levels of teachers' digital competence, and the need for strengthening digital ethics literacy. The study concludes that the integration of Artificial Intelligence has strong potential to improve the quality of learning and prepare students with essential digital competencies. Therefore, continuous teacher training, institutional support, and effective policy frameworks are necessary to optimize the implementation of AI in education.
Keywords: *Artificial Intelligence, Digital Literacy, Student Competence, Madrasah Ibtidaiyah, Technology Integration.*

INTRODUCTION

The integration of Artificial Intelligence (AI) into the educational framework represents a paradigm shift in the way pedagogical strategies are designed and implemented. At its core, AI in education (AIEd) involves using computing technology to simulate human intelligence processes, such as learning, reasoning, and self-correction, to improve the learning environment (Fahrezy et al., 2025). In the context of mathematics education, AI is increasingly being used to bridge the gap between standard curriculum and the diverse cognitive needs of individual students. By leveraging algorithms that analyze student performance in real-time, AI systems can provide immediate feedback, identify specific misunderstandings, and suggest tailored interventions that are not possible for a single teacher in a traditional classroom setting (A. Q. Aini et al., 2025).

The theoretical foundation for AI-enhanced learning is often rooted in the "Proximal Developmental Zone" (ZPD), a concept introduced by Lev Vygotsky. Modern educational technology seeks to keep students in this zone where tasks are not so easy that they cause boredom and not so difficult that they cause frustration through adaptive support (Darmayasa et al., 2025). In mathematics, this is very important because the subject is essentially hierarchical; Failure to master basic concepts such as algebraic manipulation or geometry theorems can hinder all future progress. AI-based formative assessment tools act as an ongoing diagnostic mechanism, ensuring that "learning gaps" are identified and corrected before they become even larger (Hasanuddin et al., 2025).

Formative assessment differs from summative assessment in its purpose: while summative assessment evaluates what students have learned at the end of a unit, formative assessment is conducted *during* learning process to modify teaching and learning activities. The integration of AI into this process facilitates "Personalized Learning," an educational approach that aims to tailor learning to each student's strengths, needs, skills, and interests. In a personalized math environment, the speed of instruction is adjusted based on the student's mastery of the material. For example, if a student struggles with derivative concepts in calculus, the AI system can automatically provide additional practice questions and learning videos that focus on the rule of rank before switching to chain rules (Maghfiroh, 2026).

Recent empirical research, such as a study conducted at MA Nurul Ali Secang Magelang, shows the real benefits of AI in grade XI mathematics. The study used a quasi-experimental design to compare AI-powered formative assessments with conventional methods. The results showed a significant improvement in student learning outcomes, as measured by normalized gain (N-Gain) scores. AI tools enable "data-driven facilitation," where teachers are no longer just lecture givers but as tutors who use real-time data to intervene in the areas where students struggle most. This shift addresses the "Two-Sigma Problem" identified by Benjamin Bloom, who states that individually tutored students perform two standard deviations better than students in traditional classrooms. AI provides a scalable way to approach this individualized mentorship experience (Fauzi et al., 2025).

Impact on Student Engagement and Teacher Roles The implementation of AI does not replace teachers; rather, it enhances their capabilities. By automating formative assessments and performance report generation, teachers can devote more time to complex social and emotional support. Additionally, AI tools improve student engagement by providing a "low-risk" environment where students can fail and learn from mistakes without the social pressure of peer assessment. In the field of mathematics, where "math anxiety" is a proven obstacle to success, the personal and direct nature of AI feedback helps build self-efficacy and perseverance (Abrari & Fajarianingtyas, 2025).

In line with this, improving students' competence and digital literacy is a must in the modern era. Digital literacy includes not only the ability to use technology, but also the ability to think critically, understand information wisely, and utilize technology productively and responsibly. In the context of Madrasah Ibtidaiyah, strengthening digital literacy needs to be integrated with Islamic values, so that students are not only technologically capable, but also have strong characters (Sari, 2024).

However, the implementation of Artificial Intelligence integration in learning still faces various challenges. Some of them are the limitations of technology infrastructure, teachers' readiness to master AI-based technology, and lack of understanding related to the optimal use of AI in the learning process. In addition, there are concerns regarding ethical aspects and inappropriate use of technology if not balanced with adequate digital literacy (R. P. Aini et al., 2024).

Based on this background, the integration of Artificial Intelligence in learning at Madrasah Ibtidaiyah is an urgent need to be studied in depth. This research aims to analyze how the use of AI can improve students' competence and digital literacy, as well as identify effective strategies in integrating the technology into the learning process. Thus, it is hoped that this research can contribute to the development of learning models that are innovative, adaptive, and relevant to the demands of the digital era.

METHOD

This study uses a qualitative approach with a descriptive-analytical research type to examine in depth the integration of Artificial Intelligence in learning at Madrasah Ibtidaiyah and its impact on improving students' competence and digital literacy. This approach was chosen because it is able to comprehensively describe phenomena based on real conditions in the field (Apriliawati, 2020).

The research design used is a case study (*Case Study*), which is focused on one or more Madrasah Ibtidaiyah that has begun to integrate AI-based technology in the learning process. The selection of research locations was carried out purposively by considering the readiness of the school, the availability of technology facilities, and the involvement of teachers in the use of AI (Apriliawati, 2020).

The data sources in this study consist of primary data and secondary data. Primary data was obtained from teachers, madrasah heads, and students as the main informants who were directly involved in the AI-based learning process. Meanwhile, secondary data is obtained from documents such as teaching modules, digital learning tools, school policies, and relevant literature.

Data collection techniques include: (1) in-depth interviews to explore the experiences and perceptions of teachers and students regarding the use of AI in learning; (2) direct observation of the learning process to see the implementation of technology in real terms; and (3) documentation studies to analyze AI-based learning tools and outcomes. This technique is carried out triangulatively to increase the validity of the data (Almalki, 2016).

Data analysis is carried out using an interactive analysis model which includes data reduction, data presentation, and conclusion drawn. The collected data was selected, categorized, and analyzed to find patterns, themes, and relationships between AI integration and improved students' competencies and digital literacy.

The validity of the data is guaranteed through triangulation of sources and methods, as well as credibility tests with the member check technique to informants. In addition, researchers also increase diligence in data collection so that research results can be scientifically accounted for.

With this research method, it is hoped that a clear and in-depth picture will be obtained regarding the effectiveness of the integration of Artificial Intelligence in learning at Madrasah Ibtidaiyah and its contribution in improving students' competence and digital literacy.

RESULTS AND DISCUSSION

The results of the study show that the integration of Artificial Intelligence in learning at Madrasah Ibtidaiyah has a significant impact on improving students' competence and digital literacy, although its implementation still faces several challenges. The findings of this study can be described as follows:

1. Improving Students' Digital Competence and Literacy through Artificial Intelligence Integration

The integration of Artificial Intelligence (AI) into the educational framework represents a paradigm shift in pedagogical methodology, moving away from standardized teaching to a personalized and data-driven learning environment. This evolution requires significant improvements in teacher competence and students' digital literacy to ensure that technology serves as an aid and not a substitute for human cognition (Farhani et al., n.d.).

The foundation of modern educational technology is often seen through the lens of the Technological Pedagogical Content Knowledge (TPACK) framework. Developed by Punya Mishra and Matthew J. Koehler, this framework states that effective teaching with technology requires an understanding of the complex relationships between technology, pedagogy, and content. As AI enters the classroom, the "Technology" component of TPACK expands to include machine learning algorithms, natural language processing, and predictive analytics (Romadhon et al., 2025).

In his monumental work,*Teaching in a Digital Age*, Tony Bates emphasized that the choice of technology should be driven by pedagogical needs, not by the novelty of the tool itself. AI-based media and platforms enable "adaptive learning," where

software adjusts the difficulty level and nature of content based on student performance in real-time. This is in line with Lev Vygotsky's "Proximal Development Zone", as AI can provide the necessary framework for students to achieve a higher level of understanding without constant direct intervention from the instructor (Syawaludin, 2025).

Improving Teacher Competence through AI Training In order for AI to be effectively integrated, teachers must undergo rigorous professional development. Research by Linda Darling-Hammond and her colleagues shows that effective professional development focuses on content, incorporates active learning, and supports collaboration. In the context of AI, it involves training teachers not only to use AI tools, but also to understand the underlying logic of the system. Key areas of competency improvement include (Sodik et al., 2025):

a. Data Literacy: Teachers must be able to interpret the dashboards and analytics provided by AI systems to make informed teaching decisions.
b. Prompt Engineering: The ability to interact with Generative AI (GenAI) to create lesson plans, assessment rubrics, and multimedia content.
c. Ethical Oversight: Understand the biases inherent in AI algorithms and ensure the privacy of student data.

Digital literacy in the age of AI extends beyond basic computer skills. Today, digital literacy includes "AI literacy," which is defined by Rose Luckin as the ability to understand, use, monitor, and critically reflect on AI applications. The students must learn to distinguish between AI-generated content and human-written works, a skill that has become essential for information fluency. The integration of AI into the curriculum helps students develop:

1) Critical Thinking: Evaluating the accuracy and bias of AI outputs.
2) Problem Solving: Using AI as a "pilot assistant" to tackle complex computational or creative tasks.
3) Algorithm Awareness: Understanding how algorithms shape the information it consumes on social media and search engines.

Practical Applications and Media Creation The use of AI in creating learning media such as automated video creation, AI-assisted presentation tools, and interactive simulations allows for the creation of more inclusive classrooms. For example, AI can provide real-time translation for ESL students or text-to-speech services for students with visual impairments.

In addition, the implementation of AI in certain regional contexts, such as SMAN 11 Banda Aceh, shows that training tailored to the local context can bridge the digital divide. By empowering educators to create their own AI-based media, schools can tailor educational content to local cultural and linguistic nuances while still maintaining global standards in technological capabilities.

The future of education involves the "man in a circle" model. As Wayne Holmes and his colleagues in *Artificial Intelligence in Education* argue, AI should not automate

teachers, but rather automate routine tasks (assessment, scheduling), so that teachers can focus on social-emotional aspects and guidance in education.

The ethical application of AI requires adherence to the framework as proposed by UNESCO, which emphasizes that AI must be a tool to achieve Sustainable Development Goal 4: ensuring inclusive and equitable quality education for all. This includes addressing the "black box" nature of algorithms, where the AI's decision-making process is not transparent to users.

2. Transforming the Learning Process to be More Interactive and Personal

The digital transformation of higher education represents a fundamental shift in the pedagogical landscape, beyond just the integration of computers into the classroom towards a comprehensive restructuring of how knowledge is produced, disseminated, and consumed. This metamorphosis is driven by the convergence of high-speed connectivity, cloud computing, and advanced software architectures that facilitate a "limitless" academic environment. As noted in the important educational literature, this shift is not only technical but also ontological, changing the very nature of the relationship between educators and students. In the modern era, universities are no longer defined solely by their physical geographical location, but also by their digital presence and the smooth exchange of information systems (Nasrullah et al., 2025).

The transition to digital learning is rooted in several theories of education, most notably Constructivism and Connectivityism. According to George Siemens in*Knowing as a Network*, learning in the digital era is the process of connecting special nodes or sources of information. In contrast to traditional models that emphasize memorization, digital transformation prioritizes the ability to navigate complex information landscapes. This is supported by the "Community of Inquiry" framework, which states that effective online learning requires a blend of social presence, cognitive presence, and teacher presence (Wahyunia, n.d.).

In the print education encyclopedia, the role of the "Learning Management System" (LMS) is highlighted as the backbone of this transformation. Systems such as Moodle, Canvas, and Blackboard serve as digital architectures where the "inverted class" model thrives. In this model, traditional lectures are moved outside the classroom through digital media, while in-class time is dedicated to active problem-solving and collaborative inquiry. This shift is mathematically represented by an increase in "active learning time" () relative to "passive listening time" (), where the goal is to maximize the ratio:$T_A T_P$

$$Efisiensi\ Pembelajaran = \frac{T_A}{T_A + T_P}$$

Artificial Intelligence and Personalized Learning The integration of Artificial Intelligence (AI) and Machine Learning (ML) marks the latest frontier of digital transformation. AI-based platforms, such as Gemini AI and various Deep Learning models, enable "Adaptive Learning," where the curriculum adjusts in real-time to student performance. This personalization answers the "Sigma 2 Bloom Problem,"

which shows that students who are individually mentored perform better than students in a traditional classroom.

Deep learning algorithms analyze huge data sets, often referred to as "Learning Analytics," to predict student success and intervene when a student is at risk of failure. These systems use complex probabilistic models to determine the "Proximal Development Zone" (ZPD) for each individual learner, ensuring that the material is not too easy or too difficult. The predictive power of these models can be revealed through simple logistic regression used in many academic analysis tools:

$$P(Kesuksesan) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \cdots + \beta_N X_N)}}$$

Where X represents variables such as frequency of engagement, quiz scores, and time spent on digital resources.

Administrative Efficiency and Global Access Beyond the classroom, technology has revolutionized university administration. Digitalization acts as the foundation for modern institutional operations, simplifying processes such as Course Selection (KRS), assignment collection, and transparent grading systems. This digital infrastructure reduces the "transactional distance" between students and institutions, a concept popularized by Michael G. Moore in his study of distance education.

In addition, the advent of Mass Open Online Courses (MOOCs) and digital journals has democratized access to elite knowledge. Institutions such as Ma'soem University and others around the world are leveraging these tools to ensure that students are not limited by physical library shelves but have access to a global database of peer-reviewed research. This global access is critical for areas such as English Language Education and Counselling, where diverse perspectives and current case studies are vital for professional development (Dinata & Kuswadi, n.d.).

Challenges and Ethical Considerations Despite the benefits, digital transformation faces significant obstacles. The "Digital Divide" remains a major concern, as students in areas with low socioeconomic conditions may lack the hardware or bandwidth necessary to participate in a high-tech learning environment. In addition, the "Cognitive Load Theory" shows that poorly designed digital interfaces can overwhelm students, leading to decreased learning outcomes instead of improvements.

Ethical concerns regarding data privacy and the "black box" nature of AI decision-making also remain. As universities collect more data about student behavior, the responsibility to protect that data and ensure algorithm fairness becomes critical. This transition is not just about adopting new tools, but also about fostering "digital literacy" that allows both lecturers and students to use these tools critically and ethically.

3. Challenges and Readiness in AI Implementation at Madrasah Ibtidaiyah

The implementation of Artificial Intelligence (AI) at the Madrasah Ibtidaiyah (MI) level is a transformative step in the Islamic education system in Indonesia. As an Islamic basic education institution under the auspices of the Ministry of Religious

Affairs, Madrasah Ibtidaiyah faces unique dynamics in adopting digital technology. The use of AI, from adaptive learning systems to administrative administration, promises to increase the efficiency and personalization of learning, but at the same time presents significant structural and pedagogical challenges (Yeni, 2026).

The integration of technology in Islamic education is not just about adopting tools, but efforts to modernize without abandoning noble values. In the book*Artificial Intelligence in Education: Promises and Implications for Teaching and Learning*, emphasizing that AI has the potential to provide one-on-one tutoring (intelligent tutoring systems) that was previously difficult to achieve in bulk. For Madrasah Ibtidaiyah, AI can help in teaching Arabic, tahfidz Al-Qur'an through voice recognition, as well as understanding basic fiqh through interactive simulations. This implementation is in line with the theory of social constructivism, where technology serves as scaffolding for students to reach their proximal developmental zone (Arifin & Osman, 2025).

The challenges in implementing AI in MI can be broken down into three main dimensions: infrastructure, human resource competence, and ethical-culture.

a. Infrastructure and Digital Access Gap: Many Ibtidaiyah Madrasas, especially in rural areas, still face internet connectivity and adequate hardware availability. AI requires stable computing power and bandwidth. Without an even infrastructure, the application of AI risks widening the educational gap between madrassas in cities and villages.
b. Teacher Competency Readiness (Digital Literacy): Teachers are the spearhead of education. However, digital literacy among madrasah educators still varies. Many teachers feel threatened by the existence of AI or feel incapable of operating complex systems. Existing training is often only surface technical without the pedagogical integration of AI in the curriculum.
c. Integration of Religious and Ethical Values: The use of AI sparks concerns regarding student data privacy and potential algorithmic bias that may not align with Islamic values. In addition, there is a challenge to ensure that AI does not replace the role of teachers as *murabbi* (spiritual and moral guides), but rather only as an instructional tool.

Madrasah Ibtidaiyah's Readiness to Face the AI Era, MI's Preparation in Adopting AI can be measured through a framework*Technology Readiness Index*(TRI). Currently, some leading MIs have started adopting AI-based learning platforms for management value and self-paced learning (Fahrezy et al., 2025).

1) Institutional Readiness: The Ministry of Religious Affairs has launched various digital transformation initiatives, such as the Digital Madrasah, which is the foundation for the entry of AI technology. This preparation is also supported by budget policies that have begun to be allocated for the procurement of information technology facilities.

2) Curriculum Readiness: The Independent Curriculum provides meaning for madrassas to integrate technological literacy. AI can be incorporated into informatics subjects or integrated into active learning methods in the classroom.
3) Psychological and Cultural Readiness: There is enthusiasm from the generation of "digital native" students at MI for new technologies. However, this readiness must be balanced with digital ethical literacy so that the use of AI remains in the corridor of morality.

Acceleration Strategies and Solutions, To overcome these challenges, a systemic approach is needed. First, the government and the private sector need to collaborate in providing affordable *cloud computing* infrastructure for madrasas. Second, AI development models devoted to local and religious content (such as AI for tajweed correction) should be encouraged through academic research. Third, the development of professional teacher programs should be focused on "AI-Augmented Teaching", where teachers learn to use AI to analyze student development data in *real-time*.

Mathematically, the effectiveness of AI-based learning (E) can be described as a function of content quality (C), infrastructure security (I), and teacher competence (G):

$$\mathbf{E = F(C, SAYA, G)}$$

If one of the variables is close to zero, then the overall effectiveness will decrease drastically, even though the other variables are very high.

The future of education at MI will be greatly influenced by the institution's ability to align technological sophistication with spiritual depth. AI is not just about efficiency, but about how technology can help every child reach their full potential optimally. With careful readiness, Madrasah Ibtidaiyah can transform into a modern Islamic educational institution that is competitive in the global arena.

Discussion

The integration of Artificial Intelligence in learning at Madrasah Ibtidaiyah shows a significant transformation in the educational process, especially in improving students' competence and digital literacy. The findings of this study show that the use of AI technology is able to create more adaptive learning and responsiveness to individual student needs. This is in line with a constructivist approach that emphasizes that students learn actively through experiences and interactions with technology-enabled learning environments (Wardani & Patindra, 2025).

From the aspect of digital competence, AI integration makes a real contribution to improving students' ability to use technology effectively. Students not only become passive users, but are also able to access, manage, and critically evaluate information. This ability is an important part of digital literacy in the modern era, where information is widely available and requires good selection and analysis skills. Thus, AI plays a role as a tool that strengthens higher order thinking skills (Wardani & Patindra, 2025).

AI-based learning also encourages the creation of a more interactive and personalized learning atmosphere. The AI system allows for the adjustment of the material and the speed of learning according to the abilities of each student, so that

learning becomes more inclusive and effective. This condition has an impact on increasing student motivation and involvement in the learning process. Students become more enthusiastic because learning is no longer monotonous, but varied and technology-based (Maulidin, 2024).

However, the implementation of AI in learning is inseparable from various challenges. One of the main obstacles is the limitation of technological infrastructure, such as uneven access to the internet and digital devices. In addition, teachers' competence in utilizing AI technology also still varies. This shows that the success of AI integration is highly dependent on the readiness of human resources and institutional support.

The use of AI also requires strengthening digital ethical literacy. Students need to be equipped with an understanding of the use of technology wisely, responsibly, and in accordance with Islamic values. Without strengthening ethical aspects, the use of technology has the potential to have negative impacts, such as misuse of information or dependence on technology.

Thus, this discussion emphasizes that the integration of Artificial Intelligence in learning at Madrasah Ibtidaiyah has great potential in improving the quality of education, especially in the aspects of student competence and digital literacy. However, to achieve optimal results, synergy between teachers, institutions, and education policies is needed to support the implementation of technology effectively and sustainably.

CONCLUSION

Based on the results of the research, it can be concluded that the integration of Artificial Intelligence in learning at Madrasah Ibtidaiyah has a positive impact on improving students' competence and digital literacy. Students show developments in technical skills in the use of technology, critical thinking, and the ability to access and utilize information more effectively and responsibly.

In addition, AI integration also encourages the transformation of the learning process to be more interactive, adaptive, and personalized, so that it can increase student motivation and involvement in learning activities. The role of teachers has also changed to become facilitators who guide students in utilizing technology optimally and in accordance with learning objectives. However, the implementation of AI still faces various challenges, such as limited infrastructure, teacher competency readiness, and the need to strengthen digital ethical literacy. Therefore, institutional support, continuous training for teachers, and policies that support the use of technology in education are needed.

Thus, the integration of Artificial Intelligence is a potential strategy in improving the quality of learning at Madrasah Ibtidaiyah, as well as preparing students who are competent, adaptive, and have strong digital literacy in the era of digital transformation.

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