

Strategic Approaches to Enhancing Teacher Competence in Artificial Intelligence for the Transformation of 21st Century Education

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ABSTRACT

The development of information and communication technology, particularly Artificial Intelligence (AI), has impacted various sectors, including education. This study aims to explore strategies for enhancing teachers' competencies in mastering AI at junior high schools through educational and training programs. The main focus of this research is to understand teachers' experiences and perceptions regarding the effectiveness of AI training in improving their professional competencies for 21st-century learning. This research employs a qualitative approach with a case study design at public junior high schools in Lhokseumawe. Data collection methods include in-depth interviews, classroom observations, and the analysis of relevant documents. The findings indicate that the majority of teachers who participated in AI training reported improvements in their professional competencies, particularly in using technology for automated assessments and providing instant feedback. However, the main challenges faced by teachers include the lack of advanced training and inadequate infrastructure. School management support and collaboration among teachers were identified as crucial factors in the successful implementation of AI in the classroom.

Keywords: Teacher Competence; Artificial Intelligence; Digital Transformation; Educational Technology.

INTRODUCTION

The rapid development of technology in the era of the Fourth Industrial Revolution and the shift toward Society 5.0 has brought about significant changes in the global educational paradigm (Pratiwi, 2020). 21st-century learning demands the development of essential competencies such as critical thinking, creativity, communication, collaboration, as well as digital and technological literacy (Wijayanto et al., 2024). In this context, technology plays a crucial role as a tool to support more efficient, interactive, and innovative learning. Therefore, teachers' mastery of digital competencies becomes key to ensuring that education can accommodate these changes and prepare students for increasingly complex global challenges.

In the digital era, the role of teachers is becoming increasingly vital. In addition to being instructors, teachers function as facilitators, innovators, and agents of change who can integrate technology, including Artificial Intelligence (AI), into the learning process (Tisnawati & Sukari, 2024). The professional role of teachers is critical in achieving high educational standards, as they are responsible for ensuring that students can adapt to the rapid development of technology. Therefore, teachers' adequate mastery of digital competencies is essential to enhancing the effectiveness of technology-based learning (Hava & Babayiğit, 2025).

However, the mastery of AI technology by teachers in Indonesia still faces several challenges. One of the main obstacles is the disparity in teachers' digital competencies, which is influenced by limited training, access to adequate technology infrastructure, and low digital literacy among educators (Kiianovska, 2025). These barriers also appear in the educational context, where teachers struggle to develop digital competencies that align with local educational values and culture. Therefore, a holistic and comprehensive strategy for developing teachers' digital competencies is needed so that they can effectively utilize technology, including AI, to improve the quality of learning.

National policies through the Kurikulum present a solution to address these challenges, especially at the elementary education level. The Kurikulum is designed to provide flexibility to schools and teachers in selecting methods, materials, and media that are relevant to students' needs, including the integration of AI technology. This policy is expected to prepare the younger generation with the 21st-century skills required and enable them to adapt to the Society 5.0 era, which focuses on human-centered technology (Lestari et al., 2023).

Various studies have shown that although the adoption of technology in education is increasing, the mastery of digital competencies by teachers remains a major barrier to the implementation of technology. For example, research by (Lucas et al., 2024) found that teachers' trust in AI is influenced by their level of digital competence, which, in turn, affects the effectiveness of AI usage in teaching. (Hava & Babayiğit, 2025) also demonstrated that strong digital competency can enhance the application of Technological Pedagogical Content Knowledge (TPACK) in teaching. The importance of digital competencies among teachers and their role in integrating technology, including AI, into classroom learning is the main focus of this research. Specifically, this study focuses on learning in junior high schools (SMP), which significantly impacts the quality of education received by students and their preparedness to face global challenges in the Society 5.0 era.

Based on the above description, there are two main research questions that will be addressed in this study:

1. How do teachers' experiences and perceptions regarding the effectiveness of AI training influence their professional competencies in the context of 21st-century learning?
2. What factors support and hinder the successful implementation of strategies to enhance teachers' competencies through AI training in schools that implement Kurikulum?

LITERATURE REVIEW

Teacher competency in the 21st century encompasses pedagogical, professional, social, and personality skills integrated with digital literacy and technology skills. According to Wijaya (Wijaya, 2023), professional teachers must be able to develop learning methods that adapt to technological advancements, including Artificial Intelligence (AI), to enhance educational competency standards. With the increasing adoption of technology, AI is expected to become an effective tool in enriching students' learning experiences and assisting teachers in delivering content more efficiently and interactively. Although the importance of digital competency is widely recognized, there remains a gap in technology mastery among teachers. (Tisnawati & Sukari, 2024) identify several challenges faced by teachers, such as limited ongoing technology training, inadequate infrastructure, and resistance to changes in traditional teaching methods. This highlights the need for teacher digital competency development to ensure effective technology adoption in teaching.

Curriculum, as a strategic policy, seeks to address educational challenges in the era of Society 5.0. (Lestari et al., 2023) explain that this curriculum offers teachers flexibility to develop contextual learning, relevant to students' needs, while enabling the integration of technologies like AI in the learning process. This policy provides opportunities for teachers to be more flexible in designing materials and methods that align with the times. AI in education has a broad role, including personalized learning, automated assessments, and data analysis for better decision-making. (Pujiono, 2021) explains that AI can accelerate the evaluation process and provide faster feedback to students, allowing for more personalized learning. (Sukmawati et al., 2024) also add that AI integration in Islamic education can enrich teaching methods and bridge gaps in access to learning.

AI has great potential; however, the main challenge in its implementation is teachers' mastery of technology. (Safwan, et al., 2024) emphasize the importance of developing digital skills among teachers so they can fully utilize technology, which is crucial for the successful implementation of AI in education. (Muhadjir Anwar, 2020) Teacher professionalism development and improving digital literacy are critical and cannot be delayed in facing the challenges of the digital era. Furthermore, developing a curriculum that is relevant to technological advancements is an important step in creating flexibility for teachers to adapt technology in teaching. (Pujiono, 2021) states that a curriculum that adapts to technological developments can strengthen teachers' digital competencies, enabling them to use technology more effectively. Along with this, technology-related training, especially in AI, becomes a key aspect of teacher competency development. (Mardin et al., 2024) note that effective training can enhance teachers' technical competencies in using technology, which in turn improves the quality of learning. AI not only supports the enhancement of teachers' technical competencies but also helps create a more interactive and innovative learning environment for students.

RESEARCH METHOD

This study aims to explore strategies for enhancing teachers' competencies in mastering Artificial Intelligence (AI) through educational and training programs (diklat) conducted at public junior high schools (SMP) in Lhokseumawe, specifically SMP Negeri 5, SMP Negeri 8, and SMP Negeri 12 (Subandi, 2011). The focus of this research is directed towards gaining an in-depth understanding of teachers' experiences and perceptions regarding the effectiveness of the diklat program in improving their professional competencies in the context of 21st-century learning. The study is designed to answer two main research questions: (1) How do teachers' experiences and perceptions of the effectiveness of AI training programs enhance their professional competencies in the era of 21st-century learning? (2) What factors support and hinder the successful implementation of strategies to enhance teachers' competencies through AI training programs at schools?

A qualitative approach with a case study design is used, allowing the researcher to explore in-depth teachers' experiences and perceptions of the AI training program and its implementation at the schools. This study is exploratory and descriptive, with data collection conducted through in-depth interviews and observations, providing a comprehensive understanding of teachers' experiences and the factors influencing the success of the competency enhancement strategies. The case study design was selected because the research focuses on real-life situations in the field, involving direct interactions with participants (teachers) in a specific educational context. Data collection techniques include: (1) Semi-structured in-depth interviews to explore experiences, perceptions, perceived changes, and challenges faced by teachers after attending the training; (2) Classroom observations to directly assess the application of AI in the learning process; and (3) Document analysis of the training curriculum, training materials, and the implementation policy of the Curriculum at the schools.

The data collection procedure is carried out in several stages, starting with interviews to obtain an initial overview, followed by direct classroom observations, and ending with document analysis related to the implementation practices of the training outcomes. (Zamili, 2015) The data analysis techniques include: (1) Transcribing all interview results verbatim to ensure data accuracy; and (2) Data triangulation by comparing the results of interviews, observations, and documentation to enhance the validity of the research findings. The limitation of this research lies in the participants, who only include teachers who have attended AI training at SMP Negeri 5, SMP Negeri 8, and SMP Negeri 12 in Lhokseumawe, so the findings cannot be generalized to the entire population of teachers. In terms of timeline, the study was conducted over six months, including three months of data collection, two months of analysis, and one month for report preparation, coinciding with the implementation of the training program and post-training evaluation.

RESULTS

This study aims to explore strategies for enhancing teachers' competencies in mastering Artificial Intelligence (AI) through an education and training program (diklat) conducted at the TR Coffee Hall, involving several public junior high schools (SMP) in Lhokseumawe, with a particular focus on SMP Negeri 5, SMP Negeri 8, and SMP Negeri 12. The primary focus of this research is to examine teachers' experiences and perceptions of the effectiveness of the training program in improving their professional competencies, particularly within the context of 21st-century learning.

School	Number of Teachers	Teacher's Name
SMPN 12 LSM	4	I.S., M.S., U.S., N.
SMPN 5 LSM	5	Y.F., N., C.R., P.H., S.P.
SMPN 8 LSM	3	M.S., N., H.M.

Table 1. Number of teachers

Teachers' Experiences and Perceptions of AI Training Effectiveness

Based on the results of in-depth interviews, the majority of teachers who participated in AI training across the three SMPs in Lhokseumawe reported positive experiences in enhancing their professional competencies. The teachers expressed that they felt more prepared and confident in utilizing technology particularly AI in the teaching and learning process. Most acknowledged that the training had provided them with a better understanding of how to integrate AI into their daily instruction, although certain challenges were encountered during classroom implementation.

Teacher A from SMP Negeri 5 stated, "This training greatly helped me understand the potential of AI in automating assessments and providing faster feedback to students. However, I find it challenging to adapt AI to the diverse characteristics of my students. A similar view was expressed by a teacher from SMP Negeri 8, who noted, "The training offered new insights, especially regarding AI for personalized learning. However, the lack of follow-up training has been a barrier for me in fully implementing AI. From these interviews, it can be concluded that, although teachers recognize the benefits of AI in their practice, there is an awareness that its use remains limited and requires further guidance and support to address the challenges of its implementation.

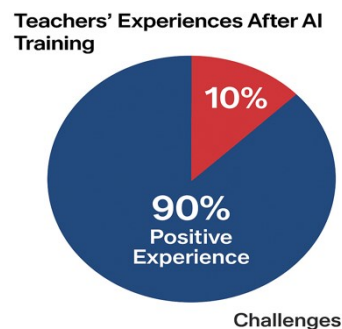


Figure 1. Positive experiences and challenges of teachers in implementing AI

The above pie chart illustrates the positive experiences and challenges faced by teachers after participating in the AI training program. A total of 90% of teachers reported positive experiences, while the remaining 10% encountered challenges in implementing AI in the classroom. This chart provides an overview of the positive impact of AI training as well as the challenges that need to be addressed to enhance the adoption of technology in education.

Supporting Factors for the Successful Implementation of AI Training

Several factors contribute to the successful implementation of strategies aimed at enhancing teachers' competencies through AI training. One of the main factors identified is support from school leadership. A teacher from SMP Negeri 12 stated, "Our principal

is highly supportive of technology integration in learning, providing facilities and granting us the freedom to experiment with new tools such as AI.” This support includes the provision of adequate devices, internet access, and allocated time for training.

In addition, collaboration among teachers also plays a significant role in the effective implementation of AI. Teachers from diverse backgrounds who share the common experience of participating in the training can exchange insights and strategies for classroom application. At SMP Negeri 5, one teacher noted, *“We often discuss new ways of using AI in teaching, which has been very helpful for me in better understanding and overcoming the challenges I encounter in class.”*

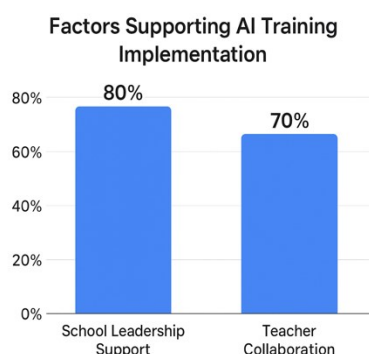


Figure 2. Supporting Factors for the Successful Implementation of AI Training

The bar chart illustrates the two main factors supporting the implementation of AI training in enhancing teachers' competencies. The first factor, school leadership support, received an endorsement rate of 80%, while the second factor, teacher collaboration, received 70% support. This chart highlights the importance of multi-stakeholder support in ensuring the successful integration of AI in the classroom.

Inhibiting Factors in the Successful Implementation of AI Training

Despite the presence of supporting factors, this study also identified several obstacles hindering the successful implementation of AI training in classrooms. One major factor is the lack of follow-up training. Many teachers felt that the training provided only a basic understanding without equipping them with the skills to apply AI in more complex contexts. A teacher from SMP Negeri 8 stated, *“The training was good, but I found it insufficient in practical aspects. I need advanced training to truly understand the implementation of AI in more diverse learning settings.”*

Infrastructure limitations also emerged as a significant barrier. Although some schools have provided devices and internet access, several teachers reported that the quality of connectivity and the equipment used remain inadequate, hindering their ability to fully leverage AI technology in teaching and learning.

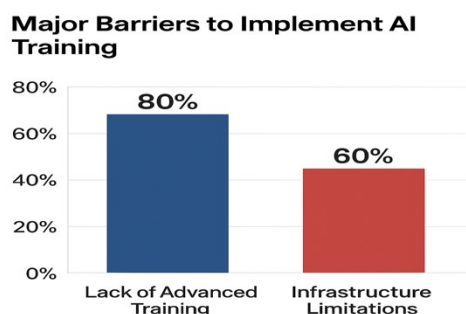


Figure 3. Inhibiting Factors in the Successful Implementation of AI Training

The above line chart illustrates the two main obstacles in the implementation of AI training. The first factor, lack of follow-up training, represents the most significant barrier at 80%, while the second factor, infrastructure limitations, accounts for 60% of the challenges. This chart provides a clear overview of the constraints faced in applying AI in classrooms, despite the presence of other supporting factors.

Classroom Observations

Classroom observations revealed that the implementation of AI by teachers at SMP Negeri 5, SMP Negeri 8, and SMP Negeri 12 remains largely limited to the use of applications for automated assessment and instant feedback. However, some teachers have begun innovating by using AI to enrich their teaching methods, such as employing AI applications to create more interactive and student-centered learning materials. The primary challenge observed is the difficulty in adapting AI usage to accommodate the diverse characteristics and learning paces of students.

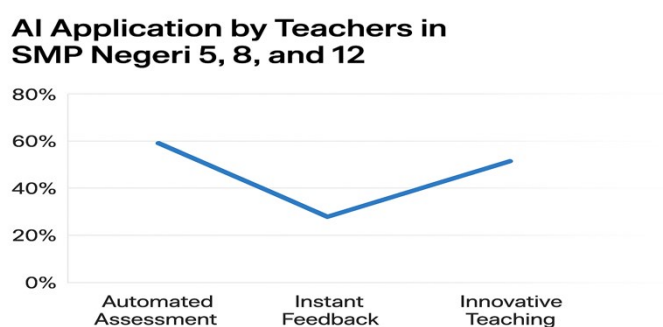


Figure 4. Classroom Observations

This statistical chart illustrates the application of AI in teaching and learning within the schools involved in the study. (Lestari et al., 2023) state that the curriculum enables greater integration of technology into education. The chart presents three main categories:

1. **Automated Assessment & Instant Feedback** – Represented by 80%, indicating that the majority of teachers use AI for automated grading and providing rapid feedback.

2. **Innovative Teaching with AI** – Represented by 70%, reflecting that some teachers have begun to innovate by using AI to enrich teaching materials.
3. **Challenges in Adapting to Students' Learning Pace** – Recorded at 60%, highlighting the greatest challenge in aligning AI technology with the diverse characteristics of students.

Data Triangulation

Data triangulation conducted across interviews, observations, and documentation revealed consistency in the findings. All data collected presented a coherent picture of teachers' experiences with AI training and the challenges encountered in its classroom application. Moreover, the triangulation confirmed that school support and advanced training are critical factors in ensuring the successful implementation of AI in education.

DISCUSSION

The implementation of Artificial Intelligence (AI) in education has demonstrated significant outcomes in enhancing teachers' professional competencies, for example through the use of ChatGPT as taught in training programs. In this study, the majority of teachers who participated in AI training reported positive experiences regarding their improved understanding of AI integration in teaching. This included making lessons more engaging and enjoyable through tools such as Canva. According to (Chung, 2025), by integrating visualization and gamification, such learning platforms not only enhance comprehension but also motivate learners to remain engaged in the learning process, thereby accelerating learning outcomes. Most teachers expressed that they felt more prepared and confident in integrating AI technology into their classrooms, particularly for automated assessment and instant feedback using Quizizz. As Y.F. from SMP Negeri 5 explained, *"After attending the training, I feel more prepared to use AI applications for assessment and personalized student learning, especially for providing quick feedback using Quizizz, which was taught in the training."* This statement aligns with (Hava & Babayiğit, 2025) findings that AI usage can improve efficiency in delivering feedback to students while enabling more personalized learning adjustments.

Despite these positive experiences, challenges in AI implementation in classrooms remain. One of the primary challenges identified was the need for advanced, contextual training. P.H., a teacher from SMP Negeri 8, emphasized the importance of more contextual follow-up training to maximize AI application across various subjects. This is consistent with (Kiiianovska, 2025) assertion that advanced training is crucial for deepening teachers' understanding of AI, particularly for integrating technology in diverse teaching contexts. Without continuous training, AI use tends to remain limited to familiar applications, such as automated assessments and instant feedback, which does not fully capture the potential of this technology for more innovative learning practices. Furthermore, adequate technological infrastructure plays a pivotal role in successful AI implementation. U.S., a teacher from SMP Negeri 12, stated that having good-quality devices and internet connectivity facilitated the application of skills learned during the training. This underscores that, despite the availability of AI training, the absence of proper infrastructure significantly limits technology adoption. (Lestari et al., 2023) similarly confirm that access to robust technological infrastructure is a key determinant in successful technology integration in education. Reliable infrastructure supports more effective AI adoption, both in classroom management and in delivering more interactive learning materials.

Collaboration among teachers also emerged as an important factor in AI implementation. Teachers from diverse backgrounds can share experiences and strategies for using AI

in education. C.R., from SMP Negeri 5, mentioned that teacher discussions were invaluable in helping them understand and overcome classroom challenges. This finding supports (Tisnawati & Sukari, 2024) argument that collaboration among educators is critical for developing digital competencies and integrating technology into teaching practices. Despite strong support from the aforementioned factors, this study also found significant barriers, one of which was time constraints. Teachers noted that heavy instructional workloads made it difficult to allocate sufficient time for optimal AI integration. This mirrors the findings of (Lucas et al., 2024), who highlighted that limited time is one of the main challenges in technology implementation, as teachers often lack the opportunity to fully master and integrate such tools into daily teaching.

The lack of advanced training was another barrier. Several teachers felt that the provided training only covered basic AI knowledge without offering in-depth insights into practical classroom applications in more complex contexts. (Mardin et al., 2024) similarly observed that advanced training with a strong practical focus is essential for teachers to optimize AI use in learning processes. (Yantu & Hinele, 2025) further stressed the importance of integrating technology into human resource management to foster a culture of innovation and enable the workforce to effectively implement digital solutions. Nevertheless, a flexible curriculum also supports AI adoption in schools. Teachers from SMP Negeri 12 stated that a curriculum allowing them to choose teaching methods and media suited to students' needs gave them the freedom to integrate AI in ways that addressed the specific requirements of their classes. This reflects (Ng et al., 2023) view that curricula adaptable to technological developments can strengthen teachers' digital competencies and support technology use in classrooms. According to (Elaine et al., 2025), the use of technology, particularly digital-based tools, also strengthens social interaction and supports accessibility in daily life, which in turn may influence individual economic behavior. In conclusion, this study demonstrates that, although there are challenges in implementing AI in classrooms, supporting factors such as technological infrastructure, school management, teacher collaboration, and curriculum flexibility provide a strong foundation for successful AI integration. However, to maximize the benefits of AI in teaching, there is a need for more in-depth and continuous advanced training for teachers, along with improvements in school technological infrastructure.

CONCLUSION

This study aims to explore strategies for enhancing teachers' competencies in mastering Artificial Intelligence (AI) at public junior high schools in Lhokseumawe City. The findings reveal that most teachers who participated in AI training reported positive experiences in improving their professional competence. They expressed greater confidence in utilizing AI technology in teaching, particularly in automated assessment and providing faster feedback. However, challenges in implementation remain, especially regarding the lack of context-specific advanced training and the difficulty of adapting AI technology to the diverse characteristics and learning paces of students. Furthermore, adequate infrastructure support and strong commitment from school management play a crucial role in the successful integration of AI in classrooms. The availability of reliable devices and stable internet connectivity greatly facilitates the adoption of this technology. Nonetheless, time constraints and the ongoing need for advanced training emerge as major obstacles that must be addressed to ensure optimal AI implementation. If you want, I can also refine this further into journal-style condensed academic prose so it reads even more like a high-impact research article abstract. That would tighten the flow and strengthen the scholarly tone.

LIMITATION

This study has several limitations that need to be acknowledged. First, there remains a strong need for more application-oriented advanced training to deepen teachers' understanding of artificial intelligence (AI) and to help them overcome challenges in implementing more complex AI applications. This limitation highlights that many teachers are not yet fully prepared to integrate AI into their daily teaching practices.

Second, the issue of technological infrastructure in schools also presents a challenge. The availability and quality of hardware are still uneven, while faster and more stable internet connectivity is essential to support the optimal use of AI in the classroom.

Third, although training has been provided, there is still a pressing need for ongoing mentorship to ensure that teachers receive continuous support when integrating AI across different subjects. Without such guidance, teachers may find it difficult to consistently apply the knowledge and skills they have acquired.

In addition, curriculum flexibility remains a limitation. A rigid curriculum can restrict teachers' ability to adapt their teaching processes to incorporate AI technology. Adjustments are needed to allow for more effective integration that aligns with students' learning needs.

Finally, the lack of teacher collaboration in sharing experiences, strategies, and best practices concerning AI implementation is another important limitation. Such collaboration is crucial to accelerating the adaptation process and maximizing the potential of AI in education.

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DECLARATION OF CONFLICTING INTERESTS

The author declares that no significant conflict of interest occurred during the preparation of this article.

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