



Analysis of the Utilization of Artificial Intelligence in the Use of Interactive Teaching Materials to Improve the Competence of Elementary School Teachers in Kudus

Fatma Fatimah¹, Sri Sukasih²

^{1,2} Universitas Negeri Semarang

Corresponding E-mail: fatmafatihmah552@students.unnes.ac.id

ABSTRACT	ARTICLE INFO
<i>This study aims to analyze how the use of Artificial Intelligence (AI) in creating interactive teaching materials can enhance the pedagogical competence of elementary school teachers. A descriptive qualitative approach was employed in the study, which was conducted across five public elementary schools in the Barongan area of Kudus City. Data were collected through interviews, Likert-scale questionnaires, and passive participant observation, and subsequently analyzed using the Miles, Huberman, and Saldana model. The findings indicate that utilizing AI platforms such as ChatGPT, Gemini, Canva, Quizizz, Kahoot, Wordwall, and AssemblrEDU significantly assists teachers in designing teaching materials that are more time-efficient, creative, and engaging for students. Although all teachers acknowledged the benefits of AI, their skill levels and understanding varied, primarily due to factors such as age and teaching experience. Key challenges identified included limited technological facilities specifically Chromebook units and Interactive Flat Panels (IFPs) as well as unstable internet connections. The study concludes that strengthening digital literacy and providing infrastructure support are crucial for optimizing the potential of AI in elementary schools.</i> © 2026 Kantor Jurnal dan Publikasi UPI	Article History: Submitted/Received 28 Apr 2026 First Revised 30 May 2026 Accepted 26 Jun 2026 First Available online 30 Jun 2026 Publication Date 30 Jun 2026 Keyword: Artificial Intelligence (AI); Interactive Teaching Materials; Teacher Competence.

1. INTRODUCTION

Education serves as the fundamental basis for developing high-quality human resources. As stipulated in Article 31, Paragraph (1) of the 1945 Constitution, every citizen has the right to receive a proper education. Furthermore, Law Number 20 of 2003 concerning the National Education System defines education as a conscious and planned effort to create an active learning environment that enables students to fully develop their potential—encompassing cognitive, affective, socio-emotional, and spiritual aspects. In this context, teachers play a crucial role as learning facilitators responsible for creating an effective, engaging, and meaningful learning atmosphere for students. To support this, teachers utilize instructional tools, one of which is teaching materials. Teaching materials consist of a collection of content designed systematically and engagingly to assist teachers in conducting the classroom learning process (Magdalena et al., 2020). Moreover, beyond the learning process itself, teaching materials play a vital role in the quality of education, including student learning outcomes. Teaching materials constitute a strategic component in achieving educational goals (Putriku et al., 2024). The fields of education and learning continue to evolve alongside technological advancements (Tundreng et al., 2023).

In today's digital era, technological advancements have impacted daily life, particularly in the fields of education and learning. Technology has transformed the ways students learn and teachers instruct, thereby enhancing the quality of education at all levels, including in primary schools. Amidst ongoing technological progress, Artificial Intelligence (AI) has emerged as a prominent technology in the educational landscape. Artificial Intelligence is a computer technology capable of mimicking human capabilities such as thinking, learning, problem-solving, and decision-making (Zhai, 2023). AI has undergone rapid development in both hardware and software systems (Wang & Liu, 2021). It has enabled the creation of various applications applicable to daily life, including within the education sector. According to UNESCO, Artificial Intelligence can help improve learning outcomes and administrative efficiency while simultaneously providing broad access to education.

Despite its significant potential to enhance the quality of learning, the implementation of Artificial Intelligence (AI) in Indonesian elementary schools faces various challenges. A primary obstacle is limited digital infrastructure. Data from Statistics Indonesia (BPS, 2022) indicates that only 5.31% of elementary schools in Indonesia have access to computers to support learning activities. This situation reveals that the majority of elementary schools lack the adequate facilities required to integrate AI technology into the learning process. Furthermore, teacher readiness to utilize AI varies. A national survey of 349 teachers across various educational levels shows that AI is beginning to be used to support the preparation of teaching materials, lesson planning, and the development of learning media. However, its utilization remains constrained by infrastructure limitations, the low relevance of AI outputs to learning needs, and uneven levels of teacher digital competence (Aisyah et al., 2026). These findings suggest that optimizing AI use in primary education requires strengthening digital infrastructure and enhancing teacher competence so that the technology can support learning effectively and sustainably.

This situation is corroborated by the results of preliminary observations conducted in March 2025 at five public elementary schools grouped into a single cluster in Kudus City.

These observations revealed that the schools had provided Chromebooks and Smart TVs as digital learning tools; however, the number of devices remained limited approximately 15 Chromebooks per school and these were shared among all students. Additionally, there were significant differences in teachers' instructional practices. Some teachers still use traditional teaching methods, such as lectures and discussions. Meanwhile, other teachers have begun integrating AI-based digital platforms such as ChatGPT, Gemini, Canva, Quizizz, Kahoot, Wordwall, and Assemlr EDU into their lessons. This situation indicates that teachers' understanding of how to utilize AI in developing interactive teaching materials remains uneven.

Interactive teaching materials are systematically organized learning resources that facilitate active, two way communication. Interactive teaching materials involve active two-way communication between teachers and students (Hartono et al., 2023). With these interactive teaching materials, students take a dominant and active role during learning activities. By utilizing AI, teachers can develop interactive teaching materials efficiently, innovatively, and in line with students' learning needs. This aligns with the principles of the "Merdeka" curriculum, which emphasizes the importance of differentiated and student-centered learning. Thus, the use of AI not only supports improvements in the quality of learning but also enhances teachers' professional and pedagogical competencies.

The use of Artificial Intelligence (AI) in education can be explained through the Technology Acceptance Model (TAM) and Technological Pedagogical Content Knowledge (TPACK) frameworks. TAM explains that the acceptance of a technology is influenced by users' perceptions of its perceived usefulness and perceived ease of use (Davis, 1989). In the context of education, teachers tend to adopt AI technologies if they believe these technologies can enhance the effectiveness of their professional tasks and support the learning process more efficiently. Recent research indicates that perceptions of benefits, levels of trust in AI, and AI literacy have a significant influence on teachers' acceptance and use of AI in learning activities (Al-abdullatif, 2024). Furthermore, the integration of AI into learning can also be understood through the TPACK framework, which emphasizes the importance of teachers' ability to integrate technological knowledge, pedagogy, and learning content in a cohesive manner (Hava & Babayiğit, 2025). In the era of digital transformation, mastery of TPACK competencies is a critical factor in supporting the effective implementation of AI. A number of studies indicate that AI-TPACK competencies contribute to teachers' readiness to utilize AI technology to design, implement, and evaluate learning that is more innovative and adaptive to students' needs (Celik, 2023).

A number of previous studies have shown that the use of AI can support the learning process. A study (Puspita et al., 2023) explains that the use of Artificial Intelligence (AI) has been proven to help elementary school teachers develop more effective and innovative teaching materials, as well as support the improvement of teachers' competencies. Furthermore, (Putra et al., 2024) emphasize that Artificial Intelligence holds great potential for improving the quality of learning in elementary schools through personalization, assessment, and increased student engagement in the learning process. These findings align with the results of a study (Gagaramusu et al., 2025) which showed that training on the use of Artificial Intelligence (AI) in the development of instructional materials can improve teachers' digital skills and increase time efficiency in lesson preparation. However, research specifically examining the analysis of AI utilization in interactive teaching materials as a means

to improve elementary school teachers' competencies as well as the various obstacles and challenges in its implementation remains limited.

Given the limitations of previous research, this study focuses on a more in-depth analysis of the use of Artificial Intelligence (AI) in learning. Artificial Intelligence (AI) is viewed as a tool that supports the educational process, while the teacher's role in terms of creativity and professionalism remains an irreplaceable element (Rahayu, 2023). Therefore, it is important to investigate how elementary school teachers utilize Artificial Intelligence (AI) in learning activities, their level of understanding and skills, as well as the obstacles they face in integrating technology into learning. The research questions to be addressed in this study are: How does the use of Artificial Intelligence (AI) in interactive teaching materials contribute to improving the pedagogical competencies of elementary school teachers? What are the teachers' understanding and skills in using AI-based interactive teaching materials in the learning process? What challenges do teachers face in integrating Artificial Intelligence (AI) into the learning process? Thus, this study is expected to address the limitations of previous research and provide a deeper understanding of the use of Artificial Intelligence (AI) in the innovation of interactive teaching materials and the improvement of elementary school teachers' competencies.

2. RESEARCH METHODOLOGY

This study employs a qualitative approach with a descriptive design. This qualitative approach was chosen because it aims to understand phenomena directly based on real-world conditions in the field and is grounded in the philosophy of postpositivism (Sugiyono, 2016). Furthermore, the data obtained are presented in the form of narrative descriptions, allowing the researcher to gain a comprehensive understanding of the use of Artificial Intelligence (AI) in the development of interactive teaching materials in elementary schools (Moleong, 2018). A descriptive design was used to systematically and accurately describe the facts and events that occurred at the research site (Hardani et al., 2020). This approach was deemed most appropriate because it aimed to gain a comprehensive understanding of how teachers utilize Artificial Intelligence (AI) in interactive teaching materials at elementary schools.

This study was conducted at five public elementary schools that are grouped together in the Kota Kudus subdistrict, Kudus Regency, Central Java Province, namely: (1) Barongan Public Elementary School 1; (2) Barongan Public Elementary School 2; (3) Barongan Public Elementary School 3; (4) Kramat Public Elementary School; (5) Glantengan Public Elementary School. These locations were selected using purposive sampling, a technique in which samples are chosen based on specific considerations and criteria aligned with the research objectives (Sugiyono, 2016). These five schools were selected because they possess characteristics aligned with the research focus, namely: (1) they already have facilities supporting digital learning, such as Chromebooks and Smart TVs; (2) they have implemented the use of digital teaching materials in the learning process; and (3) they have teachers who are familiar with or use Artificial Intelligence (AI)-based applications in learning activities. Furthermore, the five schools are part of the same cluster and thus share relatively similar administrative and educational environment characteristics, making it easier for the researcher to conduct comparisons and obtain more in-depth data.

The research subjects consisted of three main groups of informants: five school principals, five curriculum coordinators, and five classroom teachers from each school. School principals were selected because they serve as policymakers and are responsible for implementing school programs. Curriculum coordinators were selected because they play a

role in curriculum development and the implementation of technology in learning. Classroom teachers were selected because they are the direct implementers of the learning process and users of AI-based interactive teaching materials. Thus, these three groups of informants were deemed capable of providing comprehensive information regarding the use of AI from policy and curriculum management to classroom implementation.

Data collection was conducted through semi-structured interviews, Likert-scale questionnaires, and passive participant observation. First, semi-structured interviews. Interviews were conducted with school principals and curriculum coordinators at their respective schools. Interviews were chosen because they allow researchers to obtain more in-depth information while still following established guidelines ([Firmansyah, 2026](#)). Interview questions covered aspects of policies regarding the use of Artificial Intelligence (AI), school facility support, strategies for integrating Artificial Intelligence (AI) into the curriculum, as well as the challenges and barriers to its use in learning. Second, a questionnaire using a Likert scale was administered to five classroom teachers to assess their level of understanding, skills, and perspectives regarding the use of Artificial Intelligence (AI) in interactive teaching materials. Furthermore, the use of the Likert scale was deemed effective for measuring informants' opinions on the necessary aspects ([Kusumayanthi & Rusmiyati, 2021](#)). The researchers used a Likert-scale questionnaire administered to five classroom teachers. The questionnaire was designed based on predetermined indicators and used five response categories: strongly agree, agree, undecided, disagree, and strongly disagree. The questionnaire consisted of five main aspects: understanding of AI concepts, the use of AI in developing interactive teaching materials, the contribution of AI to improving teacher competence, the impact of AI use on learning, and the obstacles and challenges of implementing AI. Before use, the questionnaire was first reviewed by experts in education and learning technology to ensure content validity. Third, passive participant observation was conducted directly in the school environment and classrooms. At this stage, the researcher did not participate in learning activities but observed the condition of technological facilities, the use of digital devices, interactions between teachers and students, and the practice of using AI-based instructional materials during the learning process. The observation results were recorded in observation sheets and field notes to support the data from the interviews and questionnaires. These observations helped the researcher obtain relevant data reflecting real-world conditions without becoming involved in the activities being observed ([Assoc & Tarusha, 2024](#)).

The data in this study were analyzed using the Miles, Huberman, and Saldana model, which comprises three main stages: data reduction, data presentation, and drawing conclusions ([Miles et al., 2020](#)). The data reduction stage is the process of selecting, focusing, and transforming data derived from field notes. [Hardani et al., \(2020\)](#) state that data reduction is a part of the analysis that guides the selection of what is necessary and what is not, thereby enabling clear conclusions to be drawn. Next, the data is presented in a descriptive-narrative format, allowing the researcher to identify well organized patterns of relationships and facilitating the drawing of conclusions. The final stage drawing conclusions is carried out through an iterative process of interpretation accompanied by verification, an effort to ensure consistency and alignment between the findings and the data obtained.

To ensure the validity and credibility of the data, this study employed source triangulation and methodological triangulation. Source triangulation was conducted by comparing information obtained from the school principal, the curriculum coordinator, and

classroom teachers. Meanwhile, methodological triangulation was conducted by comparing the results of interviews, questionnaires, and observations. In addition to triangulation, the researcher also applied member checking by asking informants to review summaries of interview results to ensure the accuracy of the information provided. Data reliability was maintained through the use of the same interview guidelines and observation sheets for all informants, systematic documentation of the research process, and the storage of transcripts and field notes as an audit trail. With these steps, the data obtained is expected to possess adequate levels of credibility, transferability, dependability, and confirmability.

3. RESEARCH RESULTS AND DISCUSSION

The results of this study were obtained from data collected through semi-structured interviews, Likert-scale questionnaires, and passive participant observation at five schools. The data were then presented based on three predefined research questions, namely: (1) the use of AI in interactive teaching materials to enhance teachers' pedagogical competencies; (2) teachers' understanding and skills in using AI-based interactive teaching materials in the learning process; and (3) the challenges teachers face in integrating AI-based interactive teaching materials into the learning process. The findings for each research question are presented in a descriptive-analytical manner, prioritizing the informants' accounts as empirical evidence.

3.1 The Use of AI in Interactive Teaching Materials to Enhance Teachers' Pedagogical Competence

Findings from a study conducted at five public elementary schools in the Barongan Cluster, Kudus City, indicate that the use of Artificial Intelligence (AI) in designing interactive teaching materials has had a significant impact on improving teachers' pedagogical competencies. The integration of Artificial Intelligence (AI) into the learning process not only simplifies instructional design but also supports teachers in adopting approaches that are more innovative, creative, adaptive, and student-centered. Teachers use various AI platforms according to their individual needs. For example, they use ChatGPT and Gemini to set learning objectives, develop instructional materials, and design learning pathways, thereby saving time. Meanwhile, Canva helps them prepare engaging visual media and create more interactive and effective presentations. When it comes to assessing learning, teachers commonly use interactive, game-based platforms that offer a variety of engaging templates, such as Quiziz, Wordwall, and Kahoot. These platforms boost student participation in a more enjoyable way. Additionally, Assemblr EDU helps teachers provide more concrete learning experiences through 3D AR visualizations, making the material easier to understand.

Furthermore, support from school principals plays a crucial role in the use of Artificial Intelligence (AI) in educational institutions. The principal of Barongan Public Elementary School 1 stated that Artificial Intelligence (AI) has been integrated into the school's curriculum. This policy is supported by the provision of 15 Chromebooks, Smart TVs, or interactive flat-panel displays (IFPs) in every classroom, Wi-Fi access covering all rooms, and collaboration with universities to conduct Artificial Intelligence (AI)-based training. Meanwhile, although other elementary schools have not yet fully integrated AI into their teaching, they continue to support teachers in utilizing this technology and are collaborating with Djarum Foundation partners to provide training in AI, robotics, and coding.

Overall, the five schools in the Barongan cluster have provided facilities to support technology-based learning. However, the distribution of these devices is not yet uniform across all classrooms. Currently, only SD Negeri 1 Barongan has a Smart TV or Interactive Flat Panel (IFP) in every classroom, while the other schools have about three units that are used on a rotating basis. This situation indicates that support from educational institutions, both formal and informal, plays a role in creating an environment that supports the sustainable implementation of Artificial Intelligence (AI), as stated by ((Kazmaci et al., 2025)

The results of the questionnaire administered to the five classroom teachers showed that all teachers (100%) agreed or strongly agreed that Artificial Intelligence (AI) has a positive impact on improving pedagogical competence. Approximately 60% of the teachers strongly agreed with all aspects assessed. The teachers also noted that Artificial Intelligence (AI) plays a crucial role in saving time when creating teaching materials, as well as in fostering innovation and creative ideas for developing classroom learning strategies. This aligns with the findings of (Zhou et al., 2024), which indicate that the use of ChatGPT can help teachers improve instructional design and provide content relevant to students' needs.

The results of this study reinforce the view (Puspita et al., 2023) that the use of Artificial Intelligence (AI) significantly helps elementary school teachers create more effective and innovative teaching materials. In line with this study, (Mambu et al., 2023) emphasize that Artificial Intelligence (AI) can help make learning more adaptive, facilitate the implementation of game-based learning, and enhance interaction with students. In this study, teachers' use of digital platforms such as Kahoot, Quiziz, and Wordwall serves as concrete evidence of the application of Artificial Intelligence (AI) in elementary school settings. Furthermore, Assemblr EDU, as an Augmented Reality platform, has been shown to increase student participation in learning. (Damayanti & Putra, 2024) explain that Augmented Reality media based on Assemblr EDU helps improve student learning outcomes because it can present material in a more concrete and interactive three-dimensional format (Nevrelova et al., 2024) support this finding by stating that Augmented Reality technology helps students visualize abstract concepts. This aligns with the social constructivist approach to learning. These findings are reinforced by a study (Sukasih et al., 2024), which confirms that Augmented Reality-based learning media significantly improves the learning outcomes and critical thinking skills of elementary school students.

The findings of this study are consistent with (Putra et al., 2024), who state that Artificial Intelligence (AI) has the potential to improve the quality of learning through adaptive learning, formative assessment, and increased student participation. This is in line with the study by (Sukasih, 2024) in the Journal of Management World, which states that the integration of game-based AI can increase students' motivation to learn. In learning activities, teachers use Artificial Intelligence (AI) to help implement diverse learning approaches in accordance with the Merdeka curriculum; for example, by creating more varied worksheets based on their level of difficulty. This statement reinforces the view of (Yu, S., & Lu, 2021) that Artificial Intelligence (AI) serves as a tool that supports teachers' work efficiency without diminishing their creativity. Furthermore, (sukasih et al., 2022) demonstrate that the use of AI via the Quiziz platform to support assessment in differentiated instruction can enhance teachers' understanding and skills, as well as make students more engaged.

Furthermore, other studies consistent with this theory indicate that teachers utilize various AI platforms to support the planning, implementation, and evaluation of learning.

This phenomenon can be explained by the Technology Acceptance Model (TAM), which states that technology acceptance is influenced by perceived usefulness and perceived ease of use (Davis, 1989). Teachers view platforms such as ChatGPT, Gemini, and Canva as technologies capable of saving time and helping to produce more engaging instructional materials. These perceptions drive increased acceptance and use of AI in teaching practices. These findings align with research (Al-abdullatif, 2024) showing that perceived benefits and AI literacy significantly influence teachers' acceptance of AI.

From a TPACK perspective, the use of AI demonstrates the integration of technological knowledge, pedagogy, and learning content. Teachers not only use AI as a technological tool but also adapt the results it generates to the characteristics of the material and the needs of the students. For example, the use of Canva for visualizing content, Quizizz and Kahoot for formative assessment, and Assemblr EDU for visualizing abstract concepts demonstrates the integration of technology that supports pedagogical strategies. These findings support research (Celik, 2023) affirming that AI-TPACK competencies play a crucial role in helping teachers integrate AI effectively and ethically into learning.

The following is a real-world example found in schools regarding the use of AI: the use of ChatGPT to develop teaching modules and student worksheets (LKPD). Teachers provide prompts such as learning objectives, student characteristics, and the material to be taught and ChatGPT generates a draft of learning activities that can be modified to suit the class's needs. Next, the material is developed into an interactive presentation using Canva, complete with illustrations, infographics, and instructional videos. During the assessment phase, teachers use Quizizz or Kahoot to turn questions into game-based quizzes that provide immediate feedback to students. The use of AI helps teachers save time in developing instructional materials, enhances creativity in designing learning activities, and expands teachers' ability to utilize digital technology to support student-centered learning.

In the solar system unit, for example, teachers use ChatGPT to create project-based lesson plans, Canva to design visual presentations, and Assemblr EDU to display 3D models of the planets in augmented reality. The integration of these various platforms enables students to have a more concrete and interactive learning experience, while also enhancing teachers' pedagogical competencies in managing technology-based learning.

3.2 Teachers' Understanding and Skills in Using AI-Based Interactive Teaching Materials in the Classroom

According to data from the Ministry of Education and Culture (2021), only about 25% of elementary school teachers actively use Artificial Intelligence (AI)-based technology. However, current research findings from five schools in Kudus City indicate that elementary school teachers are utilizing Artificial Intelligence (AI)-based technology. Approximately 75% of teachers at each school have already adapted to this technology. Teachers have utilized at least one Artificial Intelligence (AI) platform in the learning process.

Furthermore, survey results using a questionnaire indicate that all teachers possess sufficient knowledge of the basic concepts of Artificial Intelligence (AI). 60% of teachers strongly agreed, and the remainder agreed that teachers understand the basic concepts of Artificial Intelligence (AI), can identify AI platforms appropriate to their needs, and are capable of using Artificial Intelligence (AI) in learning activities. The findings of this study indicate that some teachers from these five schools have demonstrated an improvement in their understanding of Artificial Intelligence (AI).

These findings can be grouped into three skill-level categories, as summarized in Table 1 below.

Table 1. Categorization of Teachers' Skill Levels in Using AI Platforms

Levels	Teacher Characteristics	AI Platforms Under Control
Skilled	Young teachers, using AI independently and innovatively	ChatGPT, Gemini, Canva, Assemblr EDU, Quizizz, Kahoot, Wordwall
Growing	Most classroom teachers are already using AI as needed.	Canva, Quizizz, ChatGPT , Kahoot
Beginner	As a senior teacher, I need guidance from someone with more expertise.	Canva, Quizizz

Table 2 below lists the AI platforms used by teachers in the Barongan cluster, along with the functions of those platforms.

Table 2. Use of AI platforms by elementary school teachers in the Barongan Cluster

AI Platform	Key Features	Benefits for Teachers
ChatGPT	Developing learning objectives, instructional materials, and worksheets	Speeding up the development of instructional materials
Gemini	Developing learning materials and activities	Providing learning resources and ideas
Canva	Visual Design and Presentations	Improving the Quality of Interactive Teaching Materials
Quiziz	Game-Based Assessment	Increasing student engagement
Kahoot	Interactive Quiz	Creating an enjoyable learning experience
Wordwall	Practice and games	Supporting a variety of learning methods

Assemblr EDU	Visualisasi Augmented Reality (AR)	Making it easier to understand abstract concepts
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The data in the table above shows that many teachers are already using AI in the classroom. Various AI platforms have become commonplace in schools, such as ChatGPT, Gemini, Canva, Assemblr EDU, Quiziz, Kahoot, and Wordwall. Some teachers particularly those with less teaching experience have been using AI extensively and are more adept at utilizing it, whereas teachers with more teaching experience tend to struggle with using AI and still require guidance from more experienced colleagues. This pattern aligns with the findings of a study (Sharma, 2025), which shows that teachers who receive comprehensive training have higher levels of confidence in using Artificial Intelligence (AI), even though many professional development programs tend to focus more on technical skills than on pedagogical integration.

Topali et al., (2025) through a systematic review of 28 studies on the application of Artificial Intelligence (AI) in real-world K-12 education contexts, explain that, from a teacher's perspective, Artificial Intelligence (AI) helps enhance teachers' competencies. This is achieved by providing an in-depth understanding of students' learning patterns, presenting material and assessments tailored to students' needs, and helping teachers save time. These findings align with the experiences of teachers in the Barongan cluster, who have directly experienced the benefits of using Artificial Intelligence (AI), particularly in improving time efficiency and fostering creativity in the development of instructional materials.

The results of this study are consistent with the findings of (Alam et al., 2024), which state that training is essential for improving teachers' competencies and understanding of the use of Artificial Intelligence (AI). The five schools selected as research sites recognized the importance of implementing ongoing training programs focused on hands-on practice. The principal of Barongan 1 Public Elementary School emphasized the need for training that is straightforward and can be immediately applied in classroom instruction, while the principal of Kramat Public Elementary School stressed the importance of practical, project-based training to ensure greater relevance.

From the perspective of teacher competencies as stipulated in Law No. 14 of 2025, improving understanding and skills regarding the use of Artificial Intelligence (AI) can help enhance professional competencies, particularly in the area of technology. Furthermore, this supports pedagogical skills, especially in the effective use of technology during learning activities.

3.3 Challenges in Integrating AI-Based Interactive Learning Materials into the Learning Process.

The study identified several challenges encountered by teachers in integrating AI-based interactive teaching materials. These challenges can be classified into four main categories: (1) limitations in technological infrastructure; (2) disparities in teachers' digital competencies; (3) curricular and regulatory constraints; and (4) ethical and perceptual issues

a. Limitations in Technology Infrastructure

Infrastructure limitations are the most frequently cited challenge by school principals and teachers. The limited number of Chromebooks also means that not all students can access them at the same time, while an unstable internet connection can hinder the use of streaming-based digital platforms such as Assemblr EDU. Currently, Glantengan Public Elementary School has only 10 Chromebooks, the fewest among schools in the Barongan cluster. This situation aligns with the findings of a study (Yeter et al., 2024)), which states that disparities in technology infrastructure and a lack of teachers with skills in Artificial Intelligence (AI) are barriers to equitable education in developing countries. Furthermore, (Putra et al., 2024) emphasize that infrastructure limitations are barriers that have the potential to create disparities in the quality of Artificial Intelligence (AI) implementation within educational institutions.

b. Differences Teacher Competence

The five schools studied showed differences in digital competency levels between senior and junior teachers. Junior teachers typically adapt more quickly and are able to use artificial intelligence (AI) independently, while senior teachers often require guidance and support. In addition, senior teachers, who have more responsibilities at school, find it difficult to adapt to technological advancements.

(Kazmaci et al., 2025), in their study on the sustainable integration of Artificial Intelligence (AI) in elementary schools, emphasize the importance of teacher professional development programs that not only focus on technical training but also foster a deeper understanding of Artificial Intelligence (AI). Furthermore, (Sharma, S. R., 2025) reinforces these findings by showing that teachers who receive comprehensive training on the technical elements and their integration into learning demonstrate higher levels of Artificial Intelligence (AI) usage. These findings align with the dynamics described by (Gagaramusu et al., 2025), which clarify that structured project-based training is an effective approach to addressing the digital competency gap among elementary school teachers. In line with this, (Sukasih et al., 2022) emphasize that the use of the Canva application as a medium for visualizing interactive teaching materials has proven effective in improving the digital literacy of elementary school teachers; this is due to a significant improvement in their ability to access, select, and develop interactive teaching materials.

c. Curricular and Regulatory Challenges

The lack of official guidelines from the Ministry of Education, Culture, Research, and Technology regarding standards for integrating Artificial Intelligence (AI) into the elementary school curriculum means that each school must develop its own policies. This gives schools the flexibility to adapt to their specific needs and learning contexts. However, it also risks leading to variations in quality and a lack of consistency in the implementation of Artificial Intelligence (AI) at the elementary school level.

The gap between the pace of AI technological development and the pace of curriculum adaptation is a real challenge currently faced by curriculum coordinators at five schools. This situation aligns with the findings (Yeter et al., 2024) in their study, which confirmed that as of 2022, only 15 countries had integrated AI learning objectives into their national curricula.

d. Ethical and Perceptual Challenges

An ethical challenge related to the use of Artificial Intelligence (AI) in education is the use of content that has not been checked or verified for educational suitability. Content generated by Artificial Intelligence (AI) is general in nature and not easily understood by

students at first glance. Therefore, teachers must be careful in using it and adapt it to the needs and developmental levels of their students.

(Gouseti et al., 2024) explain that a broad understanding of the ethical implications of using Artificial Intelligence (AI) in education is essential not only from a technological perspective but also from moral and humanitarian perspectives. Furthermore, students must be equipped with the ability to think critically about issues such as digital advancements and independent learning.

4. CONCLUSION

Based on the results of the data analysis and discussion, it can be concluded that the use of Artificial Intelligence (AI) in interactive teaching materials makes a significant positive contribution to improving the pedagogical competencies of elementary school teachers in the Barongan Cluster, Kudus City. The integration of this technology has proven capable of improving the efficiency of teachers' work time, supporting innovation in learning strategies, and creating more adaptive and enjoyable interactions for students through various digital platforms such as ChatGPT, Gemini, Canva, Wordwall, Kahoot, Quizizz, and Augmented Reality-based media. Thus, the implementation of Artificial Intelligence (AI) in school settings still faces various complex challenges. First, there is a digital competency gap influenced by demographic factors, where younger teachers tend to be more adaptable than senior teachers; in this regard, senior teachers still require guidance from those with more expertise. Second, infrastructure limitations such as the limited number of Chromebooks and unstable internet connections pose obstacles to the optimal use of digital platforms. Third, the lack of official regulations or curriculum guidelines from the Ministry of Education and Culture leads to variations in the quality of AI implementation across schools. Moving forward, collaboration through ongoing project-based training and the equitable distribution of technological resources are necessary to ensure that the digital transformation of education can proceed effectively.

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