



Primary School Teachers' Technology Readiness for Artificial Intelligence Integration in Science Learning in Indonesia

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ABSTRACT

This study explores the readiness of elementary school teachers at Muhammadiyah Primary School in Bantul, Yogyakarta, Indonesia, to integrate Artificial Intelligence (AI) into science education. Utilizing a qualitative descriptive method, the research focuses on the four constructs of the Technology Readiness Index (TRI): Optimism, Innovativeness, Discomfort, and Insecurity. Data were collected through interviews, observations, and documentation involving school principals, vice principals, and Grade IV science teachers. Results reveal high optimism and innovativeness among educators toward using AI tools, such as bright projectors and digital applications, to enhance student engagement and learning effectiveness. However, discomfort and insecurity persist due to limited training and data privacy concerns. The study concludes that comprehensive training and institutional support are essential to foster a safe and efficient integration of AI in primary education.

Keywords

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Introduction

Integrating AI into education has transformed conventional teaching paradigms by introducing data-driven approaches that allow for greater personalization, real-time assessment, and adaptive feedback. In primary science education, AI presents numerous opportunities to personalize learning pathways, facilitate critical and analytical thinking, and improve accessibility to educational content across varied socioeconomic backgrounds [1]-[4]. These technologies include intelligent tutoring systems that provide tailored content, simulation-based tools that model scientific phenomena, and gamified applications that enhance student motivation and engagement. Especially in developing countries like Indonesia, AI applications offer strategic value by addressing educational disparities, supporting differentiated instruction, and enhancing learning outcomes [5]-[7]. However, the successful implementation of AI in educational environments is not solely reliant on the availability of technological infrastructure. Instead, it hinges on educators' readiness, confidence, and competence to integrate AI tools effectively into their pedagogical practices. The pedagogical transformation necessitated by AI adoption requires teachers to assume new roles as facilitators, co-learners, and designers of intelligent learning environments. Therefore, understanding the readiness of teachers to engage with such technologies becomes a critical factor in educational reform. Despite these advancements, the success of AI implementation is highly contingent upon teachers' readiness to adopt and sustain the integration of these technologies into their day-to-day classroom activities [8].

This study investigates the technology readiness of primary school teachers at SD Muhammadiyah Bantul, Yogyakarta, particularly emphasizing their preparedness to integrate AI into science education. It explores how educators perceive, adopt, and adapt to emerging AI technologies within the primary school context. The study seeks to identify not only the attitudes and competencies of teachers but also the structural, institutional, and pedagogical challenges they face. Furthermore, it aims to generate insights to guide educational policymakers, curriculum developers, and training institutions in crafting effective professional development strategies to enhance digital literacy and pedagogical innovation at the foundational education level.

Methods

This study employed a qualitative descriptive approach grounded in the principles of phenomenological inquiry. Data were collected through semi-structured interviews, participatory observations, and document analysis. The participants included the principal, vice principal, and 4th-grade science teachers. The data collection instruments were validated

through triangulation techniques, including source triangulation (multiple informants) and method triangulation (interviews and observations).

TRI, comprising four components (Optimism, Innovativeness, Discomfort, and Insecurity), was utilized as the theoretical framework to assess teacher readiness [9]. Data were analyzed using the interactive model of Miles and Huberman, which includes data reduction, data display, and conclusion drawing [10]. Table 1 shows the interview instrument.

Table 1. The Interview Instrument

No.	Aspect	Indicator
1.	Optimism	a. Your views on the use of artificial intelligence (AI) in science learning at elementary school
		b. Expectations for AI implementation to enhance science learning
		c. The positive potential of using AI technology in the educational context
		d. Strategies for self-motivation to master new technologies in learning
		e. Strategies for overcoming obstacles in using AI technology
2.	Innovativeness	a. Innovative ideas or concepts you wish to implement using AI technology in science learning
		b. Development of AI-based teaching methods to achieve learning goals
		c. Concrete steps you have taken to implement AI technology in the classroom
		d. Collaborative strategies with fellow teachers to create innovative AI-based solutions
		e. Evaluation and reflection on the results of using AI technology in learning
3.	Discomfort	a. Major challenges you face in using AI technology in learning
		b. Strategies to overcome discomfort or confusion in implementing AI technology
		c. Strategies to learn and improve understanding of AI technology
		d. Strategies to respond to uncertainty or changes in the use of AI technology
		e. Strategies to manage frustration or technical difficulties when using AI technology
4.	Insecurity	a. Feelings of uncertainty or worry about your ability to use AI technology
		b. Strategies for handling a lack of confidence in using AI in the classroom
		c. Reasons for feeling insecure about adopting AI technology in learning

Results and Discussion

A. Teacher Attitudes Toward AI: Optimism and Innovativeness

The study found high optimism among teachers regarding using AI in science education. Educators strongly believed in AI's potential to improve student engagement, personalize learning experiences, and enhance academic outcomes. The principal state that:

"Keterbaruan teknologi dalam pendidikan bergantung pada cara kita memanfaatkannya. Teknologi di SD Muhammadiyah Bantul Kota dapat membuat pembelajaran lebih menyenangkan, seperti penggunaan proyektor yang memudahkan guru dalam menyampaikan materi dibandingkan dengan metode yang tradisional seperti menulis cerita. SD Muhammadiyah Bantul Kota sangat terbantu dengan adanya penggunaan teknologi."

[The novelty of technology in education depends on how we use it. Technology at SD Muhammadiyah Bantul Kota can make learning more enjoyable, such as using projectors that make it easier for teachers to convey material than traditional methods, such as writing stories. The use of technology greatly helps SD Muhammadiyah Bantul Kota.]

Another informant, the vice principal for curriculum, expressed a similar view regarding the optimism component in the technology readiness of Muhammadiyah Elementary School teachers in Bantul City, Yogyakarta, towards the use of artificial intelligence in science learning. He stated:

"Teknologi sangat menunjang pendidikan dengan meningkatkan kualitas pembelajaran baik untuk guru maupun siswa. Penggunaan AI menjadi salah satu upaya untuk meningkatkan kualitas pembelajaran terutama dalam pembelajaran IPA. Di era digital saat ini, guru diharapkan mampu untuk mengoperasikan teknologi dalam proses pembelajaran."

[Technology greatly supports education by improving the quality of learning for teachers and students. AI is one of the efforts to enhance learning quality, especially in science education. In today's digital era, teachers are expected to be capable of operating technology in the learning process.]

Fig. 1 shows a classroom scene where a bright projector facilitates science learning. The technology enhances visual engagement and supports interactive instruction, making scientific concepts more accessible and dynamic for students.



Fig. 1. Science Learning Using a Smart Projector

This optimism was particularly evident in their willingness to explore digital tools that support interactive and student-centered learning environments [11]. Bright projectors were frequently mentioned for their ability to make science content more visual and comprehensible. At the same time, AI-driven applications like Quizlet were appreciated for providing adaptive quizzes that cater to students' varying levels of understanding [12]. Additionally, teachers highlighted the value of AI-powered platforms that track student progress in real-time, enabling more targeted feedback and differentiated instruction [13]. Rather than viewing AI as a replacement for human instruction, teachers consistently described technology as a complementary asset that enhances their pedagogical strategies and expands the possibilities for creative, inquiry-based learning [14].

Based on an interview with the principal of Muhammadiyah Elementary School in Bantul City, he stated:

"Sering dilakukan pelatihan untuk guru. Dulu, pelatihan dilakukan dengan aplikasi kinemaster untuk membuat film pendek terkait pembelajaran, baru-baru ini, pelatihan beralih ke aplikasi yang bisa diakses oleh anak-nak melalui gadget, seperti Quizlet. Ini sangat mendukung pembelajaran terutama dalam pembelajaran eksperimen IPA, sehingga guru didorong untuk memahami aplikasi yang dapat memperkaya proses belajar, termasuk menggunakan game edukasi yang dapat dijadikan sebagai salah satu metode pembelajaran yang menarik."

[Training sessions for teachers are conducted regularly. In the past, the training focused on using the Kinemaster application to create short educational videos. More recently, the training has shifted to applications students can access via their gadgets, such as Quizlet. This powerfully supports learning, especially in experimental science lessons. Therefore, teachers are encouraged to understand applications that can enrich the learning process, including using educational games as an engaging teaching method.]

Fig. 2 illustrates the learning process using an engaging teaching method incorporating AI technology in science education.



Fig. 2. The Learning Process Using an Engaging Teaching Method

Table 2 presents key findings on teachers' positive attitudes toward AI in education. It highlights two components of the Technology Readiness Index (TRI): *Optimism*, reflected in teachers' belief in the benefits of AI and its classroom use; and *Innovativeness*, shown through proactive efforts to adopt AI tools and modify lessons. These indicators suggest a high readiness and willingness to experiment with AI-enhanced learning.

Table 2. Summary of Teachers' Positive Perceptions on AI Integration

TRI Component	Observed Indicators	Outcome
Optimism	Use of AI tools in class; belief in AI's learning benefits	High readiness
Innovativeness	Adoption of AI platforms; lesson modification via AI integration	Proactive experimentation

Collaborative planning and curriculum development involving teachers and administrators were also evident, reinforcing the proactive adoption of AI-based teaching models [15]. These

collaborative practices included co-designing lesson plans that integrated AI features, holding regular workshops to explore emerging technologies [16], and establishing teacher learning communities for peer mentoring [17]. Teachers were strongly willing to innovate and experiment with new instructional strategies, often adapting existing resources to include AI tools or developing interactive modules through trial and error. School leadership supported this experimentation culture, encouraging pedagogical risk-taking and continuous improvement [18], fostering a dynamic and forward-thinking teaching environment.

B. Challenges Faced: Discomfort and Insecurity

Despite the widespread optimism among educators, integrating AI into science learning revealed significant challenges. Discomfort in handling AI tools emerged as a significant barrier, particularly among senior teachers less familiar with digital technologies. Many reported feeling overwhelmed by the complexity of AI applications, such as configuring adaptive learning systems or interpreting analytics dashboards, which fully hindered their willingness to utilize these tools [19].

Insecurity was another notable concern, stemming from worries over data privacy, the ethical use of student information, and the reliability of AI-generated content. Teachers expressed apprehension about ensuring the accuracy of educational materials produced by AI systems and safeguarding student data from misuse [20]. These feelings were often exacerbated by a lack of institutional clarity on digital ethics policies and insufficient technical support [21].

If the discomfort component experienced by teachers is high, it can affect their ability to adopt and use AI. The results of an interview with the principal of Muhammadiyah Elementary School in Bantul City revealed the following:

"Tentunya sekolah khususnya guru memiliki perasaan kekhawatiran terhadap cara menggunakan teknologi baru. Namun, disini sekolah berupaya mengatasi dengan pendekatan fleksibel dan proaktif. Melihat peluang untuk belajar dan berkembang dapat meningkatkan fleksibilitas mental serta kesiapan menghadapi perubahan teknologi yang cepat."

[Of course, schools, especially teachers, often feel anxious about how to use new technology. However, our school strives to address this flexibly and proactively. Seeing opportunities to learn and grow can enhance mental flexibility and readiness to face rapid technological changes.]

In an interview regarding teachers' technology readiness for using artificial intelligence in elementary science learning, a fourth-grade teacher emphasized the influence of the discomfort component, as follows:

"Tantangan utama dalam penggunaan AI dalam pembelajaran adalah memastikan bahwa AI mendukung dan meningkatkan pembelajaran, bukan menggantikannya. Hal ini mencakup memastikan kualitas konten akurat dan relevan, serta menyeimbangkan peran AI dengan interaksi manusia."

[The main challenge in using AI in learning is ensuring that AI supports and enhances the learning process, not replaces it. This includes ensuring the quality of content is accurate and relevant, as well as balancing the role of AI with human interaction.]

From this interview, it can be concluded that the primary challenge for teachers in using AI in the classroom is to ensure that AI functions as a tool to support and enhance the learning process, rather than replacing it. Schools initiated continuous professional development programs to mitigate these issues and improve teachers' digital competencies and confidence. Workshops, peer mentoring, and ethical training sessions were implemented to support educators in navigating the evolving technological landscape. Establishing clear guidelines and ongoing supervision gradually reduced discomfort and insecurity among teaching staff [22].

Fig. 3 illustrates one of the strategies implemented to address teachers' discomfort and concerns in using and adopting AI technology, through training programs and proactive teacher engagement.



Fig. 3. The Strategies Implemented to Address Teachers in Using and Adopting AI

Table 3 outlines teachers' main challenges in integrating AI into classroom practice, based on the Technology Readiness Index (TRI) components.

Table 3. Summary of Challenges in AI Implementation

TRI Component	Observed Challenges	School Interventions
Discomfort	Anxiety over AI complexity; limited technical know-how	Training and mentorship
Insecurity	Concerns about data privacy and AI content reliability	Ethical training, policy support

These findings align with previous studies emphasizing the importance of institutional support and teacher training in AI integration. For example, Anggari [19] highlighted that the success of AI integration in elementary education requires consistent mentoring and professional development. Similarly, Santosa [20] emphasized the significance of institutional readiness, noting that schools with strategic implementation frameworks experience smoother AI adoption. Rahmawati and Nugroho [21] explored the correlation between digital literacy programs and

increased teacher competence in AI usage. Furthermore, Prasetyo and Sari [22] found that structured programs and school policy support are pivotal in alleviating teacher discomfort and reducing insecurity related to data privacy and ethical concerns. These layered interventions illustrate how schools can play a transformative role in supporting teachers through the evolving demands of AI-based education.

Conclusion

The readiness of primary school teachers to integrate AI into science learning is influenced by enabling and inhibiting factors. High optimism and innovativeness suggest strong potential for AI adoption, while discomfort and insecurity highlight the need for targeted interventions. Continuous training, ethical oversight, and infrastructural support are essential to enhance teacher confidence and efficacy in AI technologies. These findings provide a foundational reference for policymakers and educators seeking to implement AI in primary education effectively.

Conflict of Interest

The authors declare that there is no conflict of interest.

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