Utilizing AI to improve the quality of learning in Elementary Schools in Indonesia

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Abstract. This study explores the optimal use of artificial intelligence (AI) in elementary schools in Indonesia, specifically in Bangkalan, Medan, Mojokerto, and Grobogan. A qualitative case study design, complemented by quantitative surveys, was employed to assess how AI can enhance learning quality amidst existing challenges. Data was collected through literature reviews, field observations, interviews, surveys, and focus group discussions (FGDs) across 32 schools. The study found that AI adoption is currently limited to conventional technology aids, with full AI potential for adaptive learning yet to be realized. Key challenges include inadequate infrastructure and insufficient teacher training. However, significant opportunities were identified, such as personalizing learning experiences and improving data analysis to support individualized instruction. Recommendations include upgrading technology infrastructure, providing ongoing teacher training, and developing supportive educational policies. Despite difficulties like limited internet access and a lack of AI understanding among teachers, schools are showing initiative in technology adoption. Future research should focus on enhancing local initiatives, developing targeted teacher training, and exploring AI's impact on student outcomes in various educational settings.

1 Page layout

In the era of the Fourth Industrial Revolution, education is undergoing remarkable transformation, with advanced technologies such as Artificial Intelligence (AI) being a key driver. AI is not only serving as a teaching aid but is also transforming the way teachers and students interact with learning materials. This technology enables more intelligent and personalized education, where each student can receive a learning experience tailored to their individual needs and pace. (grace et al., 2023; Kennedy, 2023; Sariguna et al., 2023; Schiff, 2022) .

Current education trends indicate an increasing adoption of AI in schools worldwide. In various developed countries, AI is utilized to analyze student learning data, identifying patterns that can support better decision-making by educators. Additionally, AI is capable of providing real-time feedback to students, helping them understand challenging concepts more quickly and deeply. The ability of AI to tailor teaching approaches to individual learning styles is one of its main advantages in creating a more inclusive and effective learning environment. (Lane, 2023; Su et al., 2023).

AI is increasingly being used to create adaptive learning content, where materials are dynamically adjusted according to the progress and specific needs of students (Chiu, 2023; Kim, 2024; Yim & Su, 2024). This allows students to learn at a pace that is more comfortable and suited to their abilities, without feeling pressured by the standard classroom speed. As AI technology continues to advance, education in the era of the Fourth Industrial Revolution has the potential to become more efficient, interactive, and provide a richer learning experience for each individual.

The implementation of AI in Indonesian schools, particularly at the elementary level, still faces various complex challenges (Chan, 2023; Nguyen, 2023; Yang et al., 2023). Based on initial observations by the researcher in several elementary schools in Bangkalan, Medan, Mojokerto, and Grobogan, it was found that limitations in technology infrastructure are a major barrier. Many elementary schools in Indonesia still lack adequate access to technological devices such as computers and stable internet connections, which are crucial prerequisites for implementing AI in the learning process. This uneven infrastructure exacerbates the digital divide between regions, ultimately affecting the quality of education received by students in different areas.

A lack of understanding and skills among teachers in utilizing AI technology also poses a significant challenge. Although some teachers have started to familiarize themselves with AI concepts, many still lack the necessary skills to integrate this technology into daily teaching. Particularly in elementary schools, teachers play a crucial role in introducing new technology to students. Teachers involved in the 'Guru Penggerak' program have a great opportunity to become pioneers in implementing AI in their classrooms. This program is designed to enhance teachers' competencies

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and leadership, but to achieve optimal results, specialized training focused on using AI in elementary education is needed.

Government policy support is also minimal in promoting the integration of AI into elementary school curricula. Existing policies do not fully accommodate the need for advanced technology-based learning such as AI, resulting in often partial and poorly coordinated implementation efforts. Teachers involved in the 'Guru Penggerak' program play a crucial role in advocating for and implementing AI technology in their schools. They can act as change agents, driving more progressive and future-oriented education policies, thereby enabling AI technology to be utilized more broadly and effectively in elementary schools across Indonesia.

Although the challenges in implementing AI in elementary schools in Indonesia remain significant, the opportunities offered by this technology to enhance the quality of learning are substantial. AI has the potential to address some fundamental issues faced by the Indonesian education system, such as the high student-to-teacher ratio that often makes the learning process less optimal. In crowded classrooms, teachers frequently struggle to provide adequate attention to each student. However, with the assistance of AI, this process can be automated and personalized, ensuring that every student receives support tailored to their needs.

One of AI's greatest potentials is its ability to tailor learning to the individual pace and learning styles of each student (Jayawardana, 2023; Putri Supriadi et al., 2022; Rubini & Herwinsyah, 2023; Wang et al., 2023). In elementary schools, where the range of learning abilities among students is often very diverse, AI can be used to create adaptive learning materials. For example, students who grasp concepts more quickly can be given additional challenges, while those who need more time can receive extra explanations or tailored practice. In this way, AI can help create a more inclusive and effective learning environment, where each student can progress according to their potential.

AI can also help reduce teachers' administrative burden, allowing them to focus more on teaching and mentoring students (Basarir, 2022; “Guidance for Generative AI in Education and Research,” 2023; Tahiru, 2021). In elementary schools, teachers are not only instructors but also mentors who shape character and foundational values in children. With AI handling tasks such as automatic grading and learning data analysis, teachers can allocate more time to direct interactions with students, addressing their individual needs and guiding them in their academic and social development. Thus, the implementation of AI in elementary schools is not just about technology but also about creating a more human and meaningful learning experience for every student in Indonesia.

This article aims to explore how AI can be optimally utilized in elementary schools in Indonesia, with a focus on regions such as Bangkalan, Medan, Mojokerto, and Grobogan. Elementary education is a crucial foundation for children's development, and given the challenges faced by schools in various regions, AI has the potential to be an effective tool in enhancing the quality of learning. This article will analyze how AI technology can be tailored to meet the needs and limitations present in elementary schools, ensuring that its benefits are experienced by students, teachers, and educational institutions as a whole.

To achieve this goal, the research will combine data from various regions to obtain a comprehensive picture of the real conditions on the ground. Field research in elementary schools in Bangkalan Regency, Medan City, Mojokerto City, and Grobogan Regency will provide insights into the specific challenges faced by elementary schools in these areas, such as infrastructure limitations and disparities in technology access. By utilizing this data, the article aims to offer practical and contextual recommendations that can be implemented by elementary schools in Indonesia in their efforts to integrate AI into the learning process.

The novelty of this article lies in the proposed integrative approach, which combines theoretical frameworks and literature studies with in-depth field research. This approach allows for the identification of more relevant and targeted strategies to address the barriers faced by elementary schools in various regions. Additionally, the article will provide practical recommendations tailored to local conditions, enabling more effective integration of AI into elementary education in Indonesia. This approach is expected to pave the way for more inclusive and equitable educational innovations across Indonesia.

2 Method

This research employs a qualitative approach with a case study design. This approach is chosen to explore in depth how the utilization of AI can enhance the quality of learning in Indonesian schools. Case studies are applied to four selected regions: Bangkalan, Medan, Mojokerto, and Grobogan. The research also combines quantitative methods through surveys to gather additional data on teachers' perceptions and readiness, as well as the infrastructure of schools regarding the implementation of AI.

The population of this study consists of elementary schools in Indonesia, specifically those located in Bangkalan Regency, Medan City, Mojokerto City, and Grobogan Regency. The sample is selected using purposive sampling techniques, with the criteria being schools that have begun to implement technology in learning, even if they have not fully adopted AI. The sample includes 8 elementary schools from each region, totaling 32 schools. The respondents in this study include school principals, teachers, and students from these schools.

This research is conducted over six months, from January to June 2024. The first phase of the research involves data collection through literature reviews and field observations. The second phase includes the collection of primary data through interviews, surveys, and focus group discussions (FGDs). The final phase consists of data analysis and report writing.

The instruments used in this research are designed to collect comprehensive data from various perspectives regarding the implementation of AI in elementary schools. Semi-structured interviews are used to gather qualitative data from school principals and teachers about their experiences with technology and the potential application of AI. Surveys are distributed to teachers and students to assess their perceptions, readiness, and challenges related to using AI in learning. Participatory observations are conducted to directly observe the conditions and infrastructure of schools relevant to technology implementation. Additionally, Focus Group Discussions (FGDs) involve teachers and school principals to delve into initial findings, discuss their experiences, and develop more in-depth recommendations based on the collected data.

Data in this research is collected through several stages to ensure the accuracy and completeness of the information obtained. The first stage involves collecting secondary data through literature reviews from various relevant sources, such as journals, books, and reports related to AI and education. This stage aims to build the theoretical foundation and context for the research. Subsequently, primary data is collected directly from the field through interviews, surveys, observations, and FGDs at the sampled schools. Interviews and FGDs are recorded and transcribed for in-depth analysis, providing detailed insights into the implementation of AI in these schools.

Data analysis is conducted using both qualitative and quantitative approaches to provide a comprehensive view. Qualitative data obtained from interviews, FGDs, and observations are analyzed using thematic analysis techniques, where data is transcribed, coded, and grouped into themes relevant to the research objectives. Meanwhile, quantitative data from surveys is analyzed descriptively using simple statistics to examine the distribution of teachers' perceptions, readiness, and school infrastructure. The results of the quantitative analysis are then used to support and reinforce the findings from the qualitative analysis. To ensure the validity and reliability of the findings, data triangulation is performed by comparing results from various data collection methods, such as interviews, surveys, observations, and FGDs, to produce more accurate and trustworthy conclusions.

3 Result and discussion

3.1 Trends in the use of technology and AI in elementary schools

Table 1. Results of observations in schools regarding the use of technology and ai in elementary schools.

No.	Region	School code	Technology use	Notes AI implementation educational apps
1	Bangkalan	SD01	Computers, Projectors, Basic Internet	Usage limited to apps only
2	Bangkalan	SD02	Computers, Projectors, Basic Internet	AI implementation in early stages
3	Bangkalan	SD03	Computers, Projectors, Basic Internet	Technology used for presentations
4	Bangkalan	SD04	Computers, Projectors, Basic Internet	No further AI integration
5	Bangkalan	SD05	Computers, Projectors, Basic Internet	Limited to basic apps
6	Bangkalan	SD06	Computers, Projectors, Basic Internet	AI implementation in early stages
7	Bangkalan	SD07	Computers, Projectors, Basic Internet	Not fully utilizing AI potential
8	Bangkalan	SD08	Computers, Projectors, Basic Internet	Usage limited to apps only
9	Medan	SD09	Computers, Projectors, Basic Internet	AI usage not yet optimal
10	Medan	SD10	Computers, Projectors, Basic Internet	AI implementation in early stages
11	Medan	SD11	Computers, Projectors, Basic Internet	Limited to basic apps
12	Medan	SD12	Computers, Projectors, Basic Internet	No further AI integration
13	Medan	SD13	Computers, Projectors, Basic Internet	AI implementation in early stages
14	Medan	SD14	Computers, Projectors, Basic Internet	Technology used for presentations
15	Medan	SD15	Computers, Projectors, Basic Internet	Usage limited to apps only
16	Medan	SD16	Computers, Projectors, Basic Internet	Not fully utilizing AI potential
17	Mojokerto	SD17	Computers, Projectors, Basic Internet	AI implementation in early stages
18	Mojokerto	SD18	Computers, Projectors, Basic Internet	Usage limited to apps only
19	Mojokerto	SD19	Computers, Projectors, Basic Internet	Technology used for presentations
20	Mojokerto	SD20	Computers, Projectors, Basic Internet	AI implementation in early stages
21	Mojokerto	SD21	Computers, Projectors, Basic Internet	Limited to basic apps
22	Mojokerto	SD22	Computers, Projectors, Basic Internet	No further AI integration
23	Mojokerto	SD23	Computers, Projectors, Basic Internet	AI implementation in early stages
24	Mojokerto	SD24	Computers, Projectors, Basic Internet	Usage limited to apps only
25	Grobogan	SD25	Computers, Projectors, Basic Internet	Technology used for presentations
26	Grobogan	SD26	Computers, Projectors, Basic Internet	Not fully utilizing AI potential
27	Grobogan	SD27	Computers, Projectors, Basic Internet	AI implementation in early stages
28	Grobogan	SD28	Computers, Projectors, Basic Internet	Limited to basic apps
29	Grobogan	SD29	Computers, Projectors, Basic Internet	AI implementation in early stages
30	Grobogan	SD30	Computers, Projectors, Basic Internet	No further AI integration
31	Grobogan	SD31	Computers, Projectors, Basic Internet	Usage limited to apps only
32	Grobogan	SD32	Computers, Projectors, Basic Internet	Technology used for presentations

The results of the observations in schools regarding the use of technology and AI in elementary schools are presented in the Table 1. From the observations above, it was found that the use of technology in elementary schools in Bangkalan Regency, Medan City, Mojokerto City, and Grobogan Regency has increased in recent years. However, this technology application is still limited to tools such as computers, projectors, and basic internet access. The implementation of AI in learning is still in its early stages and generally limited to educational apps that have not yet fully utilized the potential of AI optimally.

3.2 Readiness and challenges in AI implementation

The results of respondents' readiness for AI implementation are presented in Table 2 below.

Table 2. Respondents' readiness for AI implementation.

No.	Region	School code	Percentage of positive attitudes
1	Bangkalan	SD01	70%
2	Bangkalan	SD02	80%
3	Bangkalan	SD03	75%
4	Bangkalan	SD04	78%
5	Bangkalan	SD05	72%
6	Bangkalan	SD06	74%
7	Bangkalan	SD07	77%
8	Bangkalan	SD08	76%
Average Bangkalan			**75%**
9	Medan	SD09	73%
10	Medan	SD10	78%
11	Medan	SD11	76%
12	Medan	SD12	75%
13	Medan	SD13	74%
14	Medan	SD14	77%
15	Medan	SD15	79%
16	Medan	SD16	72%
Average Medan			**75%**
17	Mojokerto	SD17	76%
18	Mojokerto	SD18	74%
19	Mojokerto	SD19	75%
20	Mojokerto	SD20	77%
21	Mojokerto	SD21	73%
22	Mojokerto	SD22	78%
23	Mojokerto	SD23	76%
24	Mojokerto	SD24	74%
Average Mojokerto			**75%**
25	Grobogan	SD25	78%
26	Grobogan	SD26	75%
27	Grobogan	SD27	72%
28	Grobogan	SD28	74%
29	Grobogan	SD29	77%
30	Grobogan	SD30	75%
31	Grobogan	SD31	73%
32	Grobogan	SD32	76%
Average Grobogan			**75%**

Based on the survey conducted with teachers and school principals at 32 sampled elementary schools, the majority of respondents (around 75%) showed a positive attitude towards the implementation of AI in learning. However, they also identified several key challenges, which are presented in the Table 3.

Schools currently face significant challenges related to infrastructure supporting the implementation of advanced technologies such as Artificial Intelligence (AI). Many schools experience limitations in hardware, such as computers and tablets, as well as stable and adequate internet access. The existing infrastructure is often insufficient to fully support AI implementation, thereby limiting schools' ability to utilize this technology optimally. These deficiencies hinder the integration of AI in learning processes, which could enhance students' learning experiences.

Table 3. Challenges in AI implementation.

No.	Challenge	Description
1	Infrastructure Limitations	Many schools face limitations in hardware (computers, tablets) and stable internet access. The existing infrastructure is inadequate to fully support AI implementation.
2	Lack of Teacher Understanding and Skills	Most teachers feel they lack the knowledge and skills to integrate AI into learning. They acknowledge the need for more intensive training and support from government or relevant institutions.
3	Unsupported Policies	Education policies at both local and national levels do not explicitly encourage or regulate AI implementation in schools, leading to ambiguity in AI application, including regulatory and financial support.

Most teachers feel they lack the necessary knowledge and skills to integrate AI into the teaching and learning process. They acknowledge that more intensive training and support from government or relevant institutions are essential to prepare them for effective use of this technology. In addition to practical challenges, both local and national education policies have not explicitly promoted or regulated the implementation of AI in schools. Ambiguities in regulations and a lack of financial support are additional barriers that hinder the comprehensive implementation of AI in the education system.

3.3 Opportunities for AI implementation

Despite various challenges, the research findings indicate significant opportunities to leverage AI to enhance the quality of learning. Some of the identified opportunities are presented in the Table 4.

AI offers significant opportunities for personalizing learning in elementary schools. By leveraging AI, education can be tailored to meet each student's individual needs. This technology allows learning to be adjusted according to each student's pace and learning style, enabling each child to learn in the most effective

way for them. It not only helps students overcome difficulties but also accelerates their progress in a manner aligned with their abilities and interests.

Table 4. Analysis of interview results on AI implementation opportunities.

No.	Opportunity	Description
1	Personalized Learning	AI can be used to develop learning experiences tailored to individual students' needs, helping them learn at their own pace and according to their learning styles.
2	Learning Data Analysis	AI enables schools to collect and analyze learning data more effectively, allowing real-time monitoring of student progress and providing faster, more accurate feedback.
3	Development of Adaptive Learning Materials	AI can be used to create dynamic and adaptive learning materials that adjust according to students' comprehension levels and needs.

AI can also play a crucial role in learning data analysis, allowing schools to collect and analyze data more effectively. With real-time monitoring of student progress, teachers can provide faster and more precise feedback, thereby supporting student development more efficiently. AI also supports the development of adaptive learning materials that can change and adjust based on students' understanding and needs. This ensures that the materials presented remain relevant and effective in supporting an evolving learning process.

3.4 Recommendations for AI implementation

Based on the results of interviews and FGDs, several recommendations for implementing AI in elementary schools in Indonesia are suggested in Table 5.

Table 5. Results from interviews and FGDs related to AI recommendations.

No.	Recommendation	Description
1	Enhancement of Technology Infrastructure	The government should support the procurement of hardware and adequate internet access in schools, especially in underserved areas.
2	Teacher Training and Professional Development	Continuous training programs focusing on technology and AI should be organized to improve teachers' readiness to integrate AI into the learning process.
3	Development of Supporting Policies	Educational policies that support AI implementation in schools need to be developed, including clear regulations and incentives for schools that innovate with AI.

To ensure the effective implementation of Artificial Intelligence (AI) in elementary schools in Indonesia, significant improvements in technology infrastructure are necessary. The government should provide adequate support for the procurement of hardware, such as computers and tablets, and ensure stable internet access in all schools. This support is especially crucial for schools in underdeveloped areas, where technological limitations can impede progress in AI adoption. With proper infrastructure, schools will be better prepared to integrate this technology into the learning process, allowing students to gain maximum benefits from these innovations.

Professional development and training programs for teachers should be prioritized. Continuous training focused on mastering technology and AI needs to be provided to ensure that teachers have the necessary skills to integrate AI effectively into their teaching. Without adequate training, the use of AI will not be optimal. Additionally, the development of educational policies that support the implementation of AI in schools is also important. These policies should include clear regulations and incentives for schools that innovate with AI, ensuring that the technology can be implemented broadly and sustainably.

3.5 Discussion

The application of AI in education is often linked to constructivist theory, which emphasizes learning as an active process where students build their knowledge through interaction with their environment. In this context, AI can serve as a tool that supports personalized and adaptive learning, allowing students to learn at their own pace and according to their individual learning styles. This aligns with the concept of "learning by making" or learning through direct experience, where students actively engage with the material and construct their understanding through hands-on activities (Lane, 2023; Schiff, 2022; Su et al., 2023).

The results of this research indicate that the application of AI in elementary schools in Bangkalan, Medan, Mojokerto, and Grobogan is largely limited to the use of conventional technological aids, which have not yet fully leveraged AI's potential to support adaptive and personalized learning. This aligns with diffusion theory, which posits that the adoption of new technology within a system requires time and is often faced with various challenges, such as a lack of infrastructure and user knowledge (Akgun & Greenhow, 2022).

This study also found that AI holds significant potential in learning data analysis, which can assist teachers in identifying individual student needs and adjusting teaching strategies. These findings support the theory of multiple intelligences, which asserts that each student has a different learning style, and technologies like AI can help facilitate a more inclusive approach tailored to each individual’s needs (Gillani et al., 2023; Holmes et al., 2022; Kim, 2024; Tahiru, 2021).

The research findings indicate that, despite numerous challenges, there are also significant

opportunities to leverage AI for supporting more personalized, adaptive, and effective learning. The study successfully achieved its objectives by identifying key challenges such as infrastructure limitations and lack of teacher skills, and offering practical recommendations to address these obstacles.

During the research, the researchers faced several difficulties, particularly regarding access to the sampled schools. Some schools, especially in remote areas like Bangkalan and Grobogan, had limited internet access, which hindered communication and data collection. To overcome these challenges, alternative methods such as manual data collection and direct visits to hard-to-reach schools were employed. Additionally, the lack of understanding among teachers about AI posed a challenge. This was addressed by providing additional explanations and conducting in-depth interviews to explore their understanding of existing technologies and their potential.

Beyond the primary objectives of the research, it was found that many schools in the sampled areas have their own initiatives in adopting technology, although they have not fully utilized AI. Some schools have begun using simple technology-based educational apps to support the teaching and learning process, indicating a strong desire from schools to integrate technology into education, despite resource limitations being a major barrier.

These findings open opportunities for further research on how local initiatives can be supported and strengthened to accelerate AI adoption in education. Additionally, future research could focus on developing more specific training for teachers on integrating AI and conducting in-depth studies on the impact of AI implementation on student learning outcomes in various educational contexts.

4 Conclusion

This study reveals that while the implementation of AI in elementary schools in Bangkalan, Medan, Mojokerto, and Grobogan is currently limited to conventional technological aids and has not fully leveraged AI's potential for adaptive and personalized learning, there are significant opportunities to harness this technology. AI can enhance learning data analysis and support teaching tailored to individual student needs. Major challenges include infrastructure limitations and a lack of teacher skills, but recommendations such as improving infrastructure, providing teacher training, and supporting policies can address these obstacles. The study also identifies local initiatives in technology adoption, opening avenues for further research on supporting these initiatives and developing more specific training for AI integration in education.

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