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Perceptions and Challenges of Using Artificial Intelligence (AI) Among Primary School Leaders and Teachers: A Case Study at Kinabatangan Sabah

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Abstract

The Fourth Industrial Revolution (IR 4.0) has introduced significant transformations in the education sector through the integration of artificial intelligence (AI) technologies, which have the potential to enhance the effectiveness of teaching and learning processes, streamline school administration, and accelerate student assessment procedures. However, the level of AI adoption in Malaysian education remains limited, particularly in rural areas such as Kinabatangan, Sabah. This situation is influenced by various challenges, including inadequate infrastructure, and insufficient institutional support. Therefore, this study aims to explore the perceptions of primary school teachers and school administrators in Kinabatangan regarding the use of AI, identify the key challenges encountered, and analyse the factors influencing the acceptance and utilisation of AI within a rural education context.

This study adopts a qualitative research approach using semi-structured interviews involving ten teachers and school administrators from several primary schools in Kinabatangan. The data collected are analysed using thematic analysis to identify recurring patterns and key themes related to the acceptance of AI and the challenges associated with its implementation in rural educational settings.

The findings indicate varying levels of AI awareness among teachers and school administrators. While some participants perceive AI as a beneficial innovation, others remain hesitant or insufficiently prepared to adopt it in their professional practices. Key challenges identified include a lack of professional training related to AI, limitations in digital infrastructure such as poor internet connectivity, and difficulties in integrating AI technologies with traditional teaching methods. -

The findings also suggest that administrative support plays a crucial role in determining the effectiveness of AI implementation, either facilitating or hindering its adoption. This study contributes to policymakers, school administrators, teachers, as well as parents and students by providing empirical insights into the challenges and potential of AI integration in rural education. The findings may also serve as a foundation for future strategies and initiatives aimed at strengthening the use of technology within the Malaysian education system.

Keywords: Artificial Intelligence; Teacher; School Leader; IR 4.0; Kinabatangan

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1. Introduction

The Fourth Industrial Revolution (IR 4.0) has brought about radical transformations across various sectors, including education. Technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and big data are regarded as key drivers in modernising education systems, enhancing the effectiveness of teaching and learning processes, and streamlining school administration. In the educational context, IR 4.0 emphasises personalised learning, automated assessment, and improved efficiency in educational management (Ramalingam & Maniam, 2024; Chear & Norman, 2024).

At the same time, Sustainable Development Goal 4 (SDG 4) introduced by the United Nations highlights the need to ensure inclusive, equitable, and quality education for all, including learners in rural and remote areas. The implementation of IR 4.0 technologies, particularly AI, has the potential to support the achievement of SDG 4 by expanding access to quality education and promoting lifelong learning opportunities (Sidhu et al., 2024). Despite these aspirations, the implementation of IR 4.0 technologies in rural areas such as Kinabatangan, Sabah, continues to face significant challenges.

The adoption of AI in rural primary schools remains limited due to constraints in digital infrastructure, low levels of awareness among teachers and school administrators, and insufficient professional training (Mahusin et al., 2024). Additional barriers include unstable internet connectivity, a lack of technological devices, and high workloads, all of which hinder the integration of AI in school management and teaching and learning practices (Othman & Muijs, 2013). Previous studies indicate that teachers' perceptions of AI play a critical role in determining the success of its integration into educational settings.

For instance, a study conducted in Miri Sarawak, Malaysia found that social influence and perceived usefulness were significant factors affecting teachers' readiness to adopt AI technologies (Chear & Norman, 2024). Similarly, research on school administrators has revealed that technological competency among educational leaders remains at a moderate level, highlighting the need for more systematic training and increased awareness (Ramalingam & Maniam, 2024). Although various initiatives have been introduced, the level of readiness among educators and students, including younger generations such as Generation Z, remains relatively low, thereby necessitating more comprehensive policy interventions (Sidhu et al., 2024).

The success of educational transformation in rural areas is also closely linked to instructional leadership by school principals and the effectiveness of school administration. Studies have demonstrated a positive relationship between principals' instructional leadership and the performance of rural schools (Wahab & Mustapha, 2020). In addition, research on digital infrastructure emphasises that improved telecommunications access supported by AI can facilitate wider implementation of educational technologies in rural contexts (Sekaran et al., 2024).

Furthermore, the successful implementation of IR 4.0 at the community level requires comprehensive rural development interventions, including training programmes, financial support, and collaboration among government agencies (Hanapiah et al., 2022). From a human capital development perspective, AI also plays a crucial role in strengthening Technical and Vocational Education and Training (TVET) as well as Science, Technology, Engineering, and Mathematics (STEM) education. The use of AI in TVET enables technical skills training to be delivered through interactive and simulation-based learning environments (Amdan et al., 2024a).

In STEM education, AI supports students in solving complex problems, analysing data, and developing critical and innovative thinking skills (Amdan et al., 2024b). These developments align with national agendas aimed at producing a highly skilled workforce capable of competing at the global level.

Given the significant potential of AI to enhance education and support sustainable development goals, it is essential to understand the perceptions of teachers and school administrators towards this technology, particularly in rural contexts.

This study aims to explore the perceptions and challenges faced by primary school teachers and school administrators in Kinabatangan in relation to the use of AI, as well as to identify the factors influencing the level of technology acceptance within rural educational environments. Educational policy support, continuous professional development, and the provision of conducive digital infrastructure are identified as key enablers for successful implementation.

1.1. Problem Statement

Despite various initiatives aimed at promoting the use of technology in education, teachers in rural areas continue to face multiple challenges related to infrastructure, digital literacy, and technical support. Studies indicate that rural teachers demonstrate a moderate level of readiness to adopt AI technologies such as ChatGPT, largely due to limited exposure and a lack of formal training (Chang et al., 2024). Furthermore, a significant digital divide between rural and urban schools constrains rural teachers' ability to effectively utilise online learning platforms such as Google Classroom (Yap et al., 2024).

In addition, teachers' attitudes towards technology play a crucial role in the acceptance of AI in educational practices. Many teachers report that constraints such as poor internet connectivity, limited access to digital devices, and concerns regarding students' overreliance on AI hinder the implementation of AI-based teaching and learning approaches (Kamarullah et al., 2024). Within this context, teachers require more comprehensive professional development opportunities and stronger administrative support to effectively adapt to technological changes (Manimaran & Nasir, 2024; Rahman et al., 2020). Studies conducted in Sabah have shown that the use of AI tools such as ChatGPT can support the teaching of English writing skills.

However, these benefits can only be fully realised when both teachers and students have adequate access to digital resources and a clear understanding of ethical AI use. Similarly, research in Sarawak indicates that preschool teachers exhibit high readiness to use multimedia tools to enhance literacy skills, yet they continue to face constraints related to basic infrastructural facilities (Rahman et al., 2020).

Moreover, several studies highlight the need for more inclusive national strategies to address digital inequality, particularly in remote areas such as Kinabatangan. These strategies include increased investment in technological infrastructure, systematic capacity building for teachers, and education policies that support the comprehensive integration of AI within the education system (Jamil et al., 2024).

1.2. Research Objectives

- To identify the perceptions of primary school teachers and school administrators in Kinabatangan towards the use of artificial intelligence (AI) in teaching, assessment, and school management.
- To identify the key challenges and factors influencing the acceptance and use of AI among teachers and school administrators in rural school settings.
- To identify the role of school administrators in supporting or hindering the use of AI and its impact on teachers and students.

1.3. Research Questions

- What are the perceptions of primary school teachers and school administrators in Kinabatangan towards the use of artificial intelligence (AI) in teaching, assessment, and school management?
- What are the main challenges faced by teachers and school administrators in using AI, and what factors influence the acceptance of this technology?
- How do school administrators support or hinder the use of AI, and what are the effects of their roles on the implementation of AI in rural primary schools?

1.4. Significance of study

The findings of this study are expected to provide valuable contributions to several key stakeholders.

For policymakers, the study offers empirical evidence that can inform the development of education policies related to the integration of artificial intelligence (AI) in rural school contexts. Such evidence may support more targeted and context-sensitive policy decisions.

For school administrators, the findings may enhance understanding of the challenges faced by teachers and assist in identifying appropriate strategies to support the effective use of AI within schools.

For teachers, this study provides clearer insights into the potential benefits and challenges associated with the use of AI in teaching and student assessment, thereby supporting informed pedagogical decision-making.

For parents and students, the study contributes to a better understanding of the potential role of AI in improving learning processes and educational experiences in rural primary schools.

2. Literature Review

2.1. Educational Transformation through IR 4.0 Technologies

The Fourth Industrial Revolution (IR 4.0) has introduced disruptive technologies such as artificial intelligence (AI), the Internet of Things (IoT), intelligent automation systems, and big data analytics. In the educational context, these technologies have led to substantial changes in teaching methods, assessment practices, and school administration. Education is no longer confined to conventional classroom-based instruction but now encompasses virtual learning environments, digital simulations, and intelligent support systems that enable teachers to tailor instruction according to students' abilities and learning needs.

For example, IR 4.0 promotes data-driven learning and automated content adaptation through AI and machine learning. These approaches are particularly beneficial for students with special educational needs and those in rural areas who may require differentiated instructional strategies. A study by Yin et al. (2024) found that technological competency among TVET educators serves as a catalyst for more effective integration of IR 4.0 technologies, especially when continuous professional development is provided.

Furthermore, inclusive digital learning has gained momentum following the COVID-19 pandemic, with increased emphasis on digital pedagogy and personalised learning supported by AI and information and communication technologies (ICT) (Jamil et al., 2024). These technologies not only enhance flexibility and efficiency in teaching and learning processes but also strengthen educational infrastructure at the grassroots level.

2.2. AI as a Catalyst for Quality Education

Artificial intelligence is widely recognised as a key enabler in achieving quality, inclusive, and equitable education, as outlined in Sustainable Development Goal 4 (SDG 4). AI has the potential to expand access to quality learning opportunities for students who face geographical and infrastructural constraints, particularly in rural areas. For instance, AI-based intelligent tutoring systems can support students in understanding complex STEM concepts through personalised and interactive learning experiences (Amdan, Janius, & Kasdiah, 2024).

In Technical and Vocational Education and Training (TVET), AI is utilised not only to accelerate skills training but also to support the development of 21st-century competencies such as critical thinking, problem-solving, and creativity. This is evident in the application of virtual simulations and adaptive learning algorithms implemented in Malaysian TVET institutions (Amdan et al., 2024).

Moreover, AI supports students in higher education institutions by enhancing academic achievement through intelligent learning tools and student performance analytics. A study by Kaur (2021) demonstrated that the use of AI in logistics courses in Malaysia led to improvements in both practical and cognitive skills, reinforcing the effectiveness of AI as a digital learning partner. The role of AI in promoting quality education extends beyond technological advancement and contributes to long-term social and economic empowerment, particularly within underserved communities.

2.3. Challenges of AI Implementation in Rural Areas

Despite the considerable potential of AI in education, its implementation in rural areas of Malaysia continues to face significant challenges. Key issues include inadequate digital infrastructure, slow or unstable internet connectivity, and limited access to appropriate digital devices. These constraints prevent students in remote areas from fully benefiting from AI-based learning opportunities that are more readily available to their urban counterparts.

In addition, high teaching workloads and the lack of regular professional training hinder rural teachers' ability to effectively integrate AI into daily instructional practices. Ahmad et al. (2024) reported that students from B40 households showed improved academic performance following intervention programmes such as B40@PERDA; however, technology support, including AI, has yet to become a central component due to access limitations.

Socioeconomic disparities further exacerbate the digital divide. Onn (2018) found that rural students possess strong vocational potential and skills but are not sufficiently exposed to modern educational technologies. Without comprehensive infrastructure provision and systematic capacity development, AI implementation in rural areas risks remaining aspirational rather than achievable.

2.4. Teachers' Perceptions and Acceptance of AI

Teachers' acceptance and trust in AI technology constitute a critical factor in the successful integration of AI in education. Even when technology is available, a lack of psychological readiness, technical competence, and professional confidence among teachers may result in minimal or symbolic use. Many rural teachers remain sceptical about the effectiveness of AI in supporting student learning, expressing concerns about students becoming overly dependent on technology and neglecting fundamental self-directed learning skills.

Ramalingam and Maniam (2024) reported that the technological competency of school administrators in AI-based instructional technologies remains at a moderate level. This has a direct impact on teachers' motivation and readiness to adopt AI more extensively. At the same time, teachers face limitations related to technical support and insufficient time to explore new tools.

Factors such as perceived effectiveness, ease of use, peer influence, and leadership support have been shown to influence teachers' willingness to adopt new technologies, as outlined in the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Anuar et al., 2024). Accordingly, confidence-building initiatives, hands-on training, and continuous support should be prioritised to ensure meaningful acceptance of AI among educators.

2.5. Leadership Roles and Administrative Support

Effective instructional leadership by school principals and administrators plays a crucial role in fostering a culture of technology use in teaching and learning. Beyond issuing directives, school leaders are expected to act as role models by actively engaging in technology use. This includes participating in digital training programmes, supporting teachers who experiment with AI tools, and developing technology-driven school improvement strategies.

In this regard, Yusoff et al. (2019) demonstrated that the eProfiling system assists administrators in systematically identifying teachers' strengths and professional development needs in TVET settings. Similarly, policy support and digital system development guided by Enterprise Architecture (EA) have been identified as key drivers of sustainable transformation in TVET institutions (Hussein et al., 2024).

Leadership that understands teachers' needs, provides time and space for technological exploration, and demonstrates trust in the potential of AI is essential within the contemporary educational landscape.

2.6. Policy Intervention and Capacity Development Needs

The successful implementation of AI in education, particularly in rural areas, requires comprehensive and inclusive policy interventions. These efforts should extend beyond investment in technological infrastructure to include continuous teacher training, access to high-quality digital resources, and strong collaboration among government agencies, non-governmental organisations, and industry partners.

A study by Amin et al. (2023) identified weak collaboration between TVET institutions and industry as a major barrier to sustaining high-quality technical education programmes. Therefore, stronger policies are needed to align labour market demands with technology-driven TVET curricula.

Additionally, Mohamad et al. (2021) emphasised the importance of incorporating entrepreneurship development and emotional intelligence into modern education policy interventions. Without a holistic, community-centred approach, the implementation of advanced technologies risks failing to reach intended beneficiaries.

2.7. AI in STEM and TVET Education

The integration of AI in STEM and TVET education not only enhances learning effectiveness but also accelerates the development of highly skilled human capital. In STEM education, AI supports students in data analysis, experimental design, and systematic problem-solving. This is supported by findings from Amdan, Janius, and Kasdiah (2024), which indicate that AI tools improve students' understanding of science and mathematics concepts in Malaysia.

In TVET, AI enables more realistic and interactive training simulations, allowing students to practise vocational skills in virtual environments before entering real-world workplaces (Amdan et al., 2025). Furthermore, AI helps students develop confidence in problem-solving and innovative design, which are essential competencies for the future workforce in the digital economy.

Industry demand for skilled TVET graduates continues to rise. Buang and Shamsudin (2020) reported increasing demand for technically skilled graduates across employment sectors. Consequently, the integration of AI in STEM and TVET education should be sustained and expanded across all levels of the education system.

3. Research Methodology

3.1. Research Design

This study employs a qualitative research design to explore in depth the experiences, perceptions, and challenges faced by rural primary school teachers regarding the use of artificial intelligence (AI) in teaching, assessment, and school management. This approach enables the researcher to understand the social realities and local context holistically through participants' perspectives and narratives. The study is grounded in a phenomenological approach, which emphasises participants' subjective lived experiences.

3.2. Data Collection Method

The primary method of data collection is semi-structured interviews. This approach allows participants to share their views and experiences openly, while enabling the researcher to adjust questions according to the flow of the conversation. Interviews are conducted face-to-face and online (if necessary). Each interview session is audio-recorded (with participants' consent) for transcription and analysis. The interview protocol is developed based on the study objectives, focusing on perceptions, challenges, factors influencing AI acceptance, and the role of school administrators.

3.3. Sampling Method

Convenience sampling and snowball sampling are used to recruit participants. Teachers who are easily accessible to the researcher, either through professional contacts or educational networks in Kinabatangan, are selected as initial participants. These participants then refer other colleagues who may be eligible and willing to participate. This sampling strategy is appropriate for qualitative research that prioritises participants with relevant experiences and knowledge related to the study topic.

3.4. Participant Profile and Selection Criteria

A total of 10 primary school teachers from various schools in the Kinabatangan district are selected based on the following criteria:

- Currently serving in rural primary schools in Kinabatangan.
- Have experience using or exposure to educational technologies, including AI.
- Willing to participate voluntarily and provide informed responses.

Variation in participants' backgrounds in terms of teaching experience, level of technology use, and school types is intended to generate a more comprehensive understanding of the phenomenon.

3.5. Data Collection Procedure

Prior to the interviews, participants are provided with an informed consent form and assured of confidentiality and anonymity. Individual interviews are conducted for approximately 30 to 45 minutes per session. Audio recordings are handled ethically and transcribed verbatim for analysis. Online interviews are conducted through platforms such as Google Meet or WhatsApp calls, depending on participants' preferences and feasibility.

3.6. Data Analysis Technique

Data are analysed using thematic analysis. The process involves several stages:

- Verbatim transcription of interview data.
- Repeated reading to gain an overall understanding of the content.
- Initial coding of meaningful units.
- Grouping codes into themes that reflect recurring patterns.
- Developing key themes and subthemes relevant to the study objectives.

Analysis is conducted manually to identify major themes emerging from participants' narratives. Validation is carried out through supervisor review and triangulation by comparing patterns across multiple transcripts.

3.7. Research Ethics

This study complies with institutional research ethics guidelines by obtaining written consent from participants. Participant identities are protected through the use of pseudonyms, and all data are stored securely. Participants are informed about the study objectives, their right to withdraw at any time, and the use of data strictly for academic purposes.

4. Data Analysis

4.1. Perceptions of AI Effectiveness in Teaching and Assessment

Most respondents expressed positive views regarding the use of AI in teaching and assessment. AI was perceived as capable of making learning more engaging and enjoyable and assisting teachers in preparing instructional materials more efficiently. For example, one teacher stated that "*AI is very interesting and enjoyable. It helps students understand lessons more easily." In assessment, AI was described as helping teachers analyse students' performance more quickly and providing an objective overview of mastery levels. Statements such as "Analysis data can be obtained quickly and accurately" reflect teachers' confidence in AI's potential to improve data-driven digital assessment.*

4.2. Challenges of Implementing AI in Rural Primary Schools

Although AI is viewed as beneficial, its implementation in rural schools faces major constraints. Key issues raised include unstable internet connectivity, limited supporting equipment, and system limitations. In addition, several teachers acknowledged weaknesses in ICT skills and digital technology use. Statements such as "*Not skilled in ICT*" and "*Relatively low IT skills*" indicate that technical support and professional training remain insufficient even though there are a platform such as DELIMA.

4.3. The Role of School Leadership in Supporting AI Use

School administrators were found to have a strong influence on teachers' readiness and motivation to use AI in teaching. Proactive administrators who provide encouragement and resources were reported to increase teachers' willingness to try new technologies. One respondent noted that "*Administrators always provide encouragement and motivation,"* while another stated that the school "*encouraged the purchase of updated portable LCDs*." These examples suggest that supportive digital leadership contributes positively to AI acceptance. One teacher stated that "*my headmaster become a goggle trainer himself to show that everyone needs to adapt with the Era of digitalization of education".*

4.4. Factors Influencing AI Acceptance Among Teachers and Administrators

Acceptance of AI is influenced by perceived ease of use, perceived effectiveness, and teachers' technological competence. Several teachers indicated that AI is easy to use and saves time, but this depends on the user's ICT skill level. The statement "*Easy, fast, and effective if used correctly"* illustrates how practical and psychological factors jointly shape technology acceptance.

4.5. Expectations for Policy and Infrastructure Support

Teachers and administrators expressed expectations for stronger policy interventions and infrastructure support from relevant authorities such as the Ministry of Education. These include clearer AI implementation plans, provision of digital equipment, training programmes, and improved internet access in rural schools. Responses such as "Provision of sufficient infrastructure and facilities" and "Implementation of online learning several times a week to encourage AI use" indicate that institutional readiness for AI must be supported by enabling infrastructure and policy frameworks.

Overall, the findings indicate that teachers and administrators in Kinabatangan have interest and confidence in AI for education, but face technical and support-related constraints. AI acceptance depends not only on individual capability but also on leadership roles and institutional policy. Effective AI implementation requires a comprehensive approach involving continuous training, infrastructure provision, and leadership that supports innovation.

5. Discussion

5.1. Perceptions of Teachers and Administrators on AI Use in Teaching, Assessment, and School Management

The findings indicate that most teachers and school administrators in Kinabatangan hold positive perceptions towards the use of AI in education. AI is viewed as an effective tool for improving teaching effectiveness and increasing student engagement through more interactive and personalised approaches. This is consistent with evidence from Malaysian studies showing that teachers recognise AI's potential to enhance teaching and learning, particularly when supported by social influence and supportive leadership (Ting & Norman, 2024).

AI is also perceived as supporting faster and more organised preparation of teaching materials aligned with students' learning levels. Petrucco et al. (2025) reported that many teachers are open to AI adoption, although ethical concerns and uncertainty about classroom use remain (Petrucco et al., 2025).

In assessment, AI is reported to assist teachers in analysing student performance more objectively and efficiently. This aligns with Kumar and Raman (2022), who highlighted AI's potential to enhance academic administration and student evaluation processes (Kumar & Raman, 2022).

From a school management perspective, AI supports administrators in systematic data organisation and reporting. Nugroho et al. (2024) similarly found that AI can improve management processes, although limitations in training and infrastructure remain significant barriers.

Overall, the findings suggest that teachers and administrators are willing to accept AI as a form of professional support, consistent with Zulkarnain and Yunus (2023), who reported that positive teacher perceptions encourage continued AI use in primary ESL teaching (Zulkarnain & Yunus, 2023).

5.2. Challenges and Factors Influencing AI Acceptance Among Teachers and Administrators

AI implementation in rural primary schools is constrained by internet access limitations, inadequate ICT facilities, and insufficient technical support. Oh and Ahn (2024) also noted that teachers see AI as a complement to their tasks, but implementation progresses slowly due to limited technological support.

Digital skills among teachers and administrators also influence adoption. Many teachers require practical and continuous training to build confidence, consistent with Ayanwale and Sanusi (2023) in their study of STEM and non-STEM teachers.

5.3. The Role of School Administrators in Supporting or Hindering AI Use

The findings indicate that administrators who provide support such as workshops, technology equipment, and spaces for sharing best practices significantly strengthen teacher motivation. Gocen and Aydemir (2020) argued that school leadership must evolve alongside AI integration, requiring new approaches to resource management and teacher training (Gocen & Aydemir, 2020).

Conversely, the absence of guidance leads to passive and hesitant teacher behaviour. Ruslim and Khalid (2024) also reported that teachers require more strategic leadership support to guide AI integration in classrooms, particularly where differentiated instruction is needed.

5.4. Recommendations and Expectations for Education Policy

Teachers and administrators expect education policy to prioritise technology capacity development in rural contexts. Strong policy support is a key condition for sustainable AI-based education implementation. This is consistent with Petrucco et al. (2025), who emphasised continuous professional development as essential for effective GenAI integration in education.

5.4.1. Study Limitations and Recommendations for Future Research

This study was conducted within a limited scope and has several constraints. First, the small sample size, involving only ten teachers and administrators from rural primary schools in Kinabatangan, limits the generalisability of the findings.

Although qualitative research prioritises depth rather than breadth, the findings may not represent the perceptions of all educators in other rural areas in Malaysia.

Second, semi-structured interviews are subject to researcher interpretation and potential social desirability bias. In some cases, participants may have been cautious or limited in sharing information due to time constraints, the online interview environment, or concerns about confidentiality.

Third, manual thematic analysis, although guided by systematic procedures, involves an element of researcher subjectivity in coding and theme development. Although cross-checking and triangulation were implemented to strengthen credibility, interpretive limitations remain.

Fourth, the study focuses only on teachers' and administrators' perspectives and does not include students, parents, district education officers, or policymakers. This narrows the understanding of the broader ecosystem of AI acceptance in rural education.

Future research is recommended in several directions. First, studies with larger samples across multiple rural districts in Sabah or Malaysia could enable contextual comparisons and improve generalisability. Second, mixed-method research combining quantitative and qualitative approaches could provide a more comprehensive understanding of AI acceptance and effectiveness.

Future studies should also include a wider range of stakeholders such as students, parents, district officers, and ministry representatives to evaluate policy interventions and ecosystem readiness holistically. Longitudinal research could examine changes in attitudes and the long-term impact of AI use, particularly after the implementation of policies or training programmes.

Finally, future research should focus on developing and evaluating targeted professional training modules for rural teachers on ethical and effective AI use. Intervention-based studies could measure the real impact of training on teaching practices and student outcomes, and contribute to reducing the digital divide between rural and urban schools.

6. Conclusion

This study demonstrates that AI has strong potential to improve teaching effectiveness, assessment processes, and school management, particularly in rural primary schools such as those in Kinabatangan, Sabah. Most teachers and administrators reported positive perceptions of AI, viewing it as helpful for accelerating instructional material preparation, organising assessment data more objectively, and making learning more interactive and personalised.

However, successful AI implementation remains constrained by infrastructural limitations such as weak internet connectivity, insufficient digital devices, and inadequate technical support. Limited ICT skills and time constraints also hinder teachers from using AI optimally.

The findings further highlight that school administrators play a significant role in shaping teachers' acceptance of AI. Supportive leadership that provides encouragement, resources, and training increases teacher motivation to experiment with and use AI effectively in classrooms. Without clear guidance and support, AI use risks remaining minimal or symbolic.

From a policy perspective, there is an urgent need for comprehensive and inclusive interventions by education authorities. Strong policy measures should include investment in rural digital infrastructure, continuous professional development, and collaboration among schools, industry, and government agencies. Through such a holistic approach, AI can be fully leveraged to strengthen rural education and contribute to achieving SDG 4.

Overall, this study reinforces that AI implementation in rural education is not solely a technological issue. It also involves leadership, policy, professional development, and community readiness. Sustainable educational transformation through AI requires continuous commitment from multiple stakeholders to ensure effectiveness and long-term viability.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed in this publication.

Declaration on the Use of AI in Writing

I hereby declare that the use of artificial intelligence (AI) technology in the preparation of this study was limited to supportive functions aimed at improving writing quality, structural organisation, and language review. All research content, including data analysis, interpretation, and discussion, represents the researcher's original work based on empirical evidence obtained ethically and legitimately from field data.

AI was not used to generate data, fabricate information, or replace the actual research analysis process. Instead, it was used ethically and responsibly in accordance with higher education institutional research guidelines and principles of academic integrity. Any ideas, suggestions, or structural assistance provided by AI were critically reviewed, evaluated, and fully adapted by the researcher to ensure authenticity and originality.

Through this declaration, I acknowledge that full responsibility for the content of this study rests with the researcher, and that the use of technological support does not compromise the academic integrity or credibility of this document.

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