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AI-Based Learning Management Strategy to Enhance Numeracy Literacy Skills in Alignment with SDG 4

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Abstract: This study aims to explore and analyze the effectiveness of Artificial Intelligence (AI)-based learning management strategies in improving numeracy literacy skills of Elementary School Teacher Education (PGSD) students in the era of society 5.0. Using a mixed-method approach, data were collected through in-depth interviews, classroom observations, and quantitative tests. Interviews involved lecturers, students, and educational technology experts to explore implementation strategies and challenges of AI integration, while observations were conducted to observe the learning process. Quantitatively, the study used a quasi-experimental design by comparing the pre-test and post-test results between the experimental group (using AI) and the control group (conventional learning), each consisting of 32 students. Qualitative results show that AI-based learning management strategies are carried out systematically through needs mapping, selecting appropriate applications (such as GeoGebra AI and ChatGPT), and automatic monitoring of learning outcomes. AI encourages students to be more independent and interactive, although they still face technical constraints such as limited devices and internet networks. Quantitative results show a significant increase in the numeracy literacy skills of students in the experimental group compared to the control group, with the results of the independent sample t-test showing a significance value of 0.000 <0.05 and an average score difference of 10.11 points. These findings demonstrate that AI-based learning strategies are effective in strengthening students' numeracy literacy and align with the principles of Sustainable Development Goal 4 (Quality Education). Therefore, AI integration in higher education is highly relevant for advancing sustainable educational practices and preparing future educators to meet the demands of Society 5.0.

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Keywords: artificial intelligence; era Society 5.0; numeracy literacy; AI-based learning; learning management strategies.

Abstrak: *Penelitian ini bertujuan untuk mengeksplorasi dan menganalisis efektivitas strategi manajemen pembelajaran berbasis Kecerdasan Buatan (AI) dalam meningkatkan keterampilan literasi numerasi mahasiswa Pendidikan Guru Sekolah Dasar (PGSD) di era masyarakat 5.0. Menggunakan pendekatan campuran, data dikumpulkan melalui wawancara mendalam, observasi kelas, dan tes kuantitatif. Wawancara melibatkan dosen, mahasiswa, dan ahli teknologi pendidikan untuk menggali strategi implementasi dan tantangan integrasi AI, sementara observasi dilakukan untuk mengamati proses pembelajaran. Secara kuantitatif, penelitian ini menggunakan desain kuasi-eksperimental dengan membandingkan hasil pre-test dan post-test antara kelompok eksperimen (menggunakan AI) dan kelompok kontrol (pembelajaran konvensional), masing-masing terdiri dari 32 mahasiswa. Hasil kualitatif menunjukkan bahwa strategi manajemen pembelajaran berbasis AI dilaksanakan secara sistematis melalui pemetaan kebutuhan, pemilihan aplikasi yang tepat (seperti GeoGebra AI dan ChatGPT), serta pemantauan otomatis terhadap hasil belajar. AI mendorong mahasiswa untuk lebih mandiri dan interaktif, meskipun mereka masih menghadapi kendala teknis seperti keterbatasan perangkat dan jaringan internet. Hasil kuantitatif menunjukkan peningkatan yang signifikan dalam keterampilan literasi numerasi mahasiswa pada kelompok eksperimen dibandingkan dengan kelompok kontrol, dengan hasil uji t sampel independen menunjukkan nilai signifikansi 0,000 <0,05 dan selisih rata-rata skor sebesar 10,11 poin. Temuan ini menunjukkan bahwa strategi pembelajaran berbasis AI efektif dalam memperkuat literasi numerasi mahasiswa dan sejalan dengan prinsip Tujuan Pembangunan Berkelanjutan (TPB) 4 (Pendidikan Berkualitas). Oleh karena itu, integrasi AI dalam pendidikan tinggi sangat relevan untuk memajukan praktik pendidikan yang berkelanjutan dan mempersiapkan pendidik masa depan untuk memenuhi tuntutan Masyarakat 5.0.*

Kata kunci: *kecerdasan buatan; era Masyarakat 5.0; literasi numerasi; pembelajaran berbasis AI; strategi manajemen pembelajaran.*

A. Introduction

In the era of Society 5.0, the rapid development of digital technology has brought major changes in various aspects of life, including in education. The emergence of artificial intelligence technology is one of the main milestones of learning transformation in the 21st century (Calp & Bütüner, 2022). However, behind the great potential of this technology, there are still various problems that become challenges in the learning process in higher education. In this context, education is required to be able to prepare young people not only to be proficient in theoretical knowledge, but also to be able to think critically, reason logically, and adapt to rapid changes.

Unfortunately, the reality of education today shows a discrepancy between these goals and the factual achievements in the field (Southworth, 2022). One of the most striking indicators is the low literacy and numeracy skills of students, which reflects the weak mastery of basic skills that are the foundation of lifelong learning (Deda et al., 2023).

Various national and international assessments, such as the Computer-Based National Assessment (ANBK) and the Programme for International Student Assessment (PISA), consistently show that many Indonesian students still struggle with deep reading comprehension, coherent idea expression, and solving even basic mathematical problems. These deficiencies not only affect academic performance but also undermine students' readiness for the world of work and civic life. This situation indicates a growing gap between the competencies demanded in the 21st century and the learning approaches still practiced in many universities (OECD, 2023). Conventional, one-way learning models that overlook students' diverse learning needs are no longer sufficient to address the challenges of modern education. In contrast, AI has the potential to support adaptive, personalised, and data-driven learning management. AI can assist lecturers in analysing student performance in real time, providing instant feedback, and designing learning activities that align with each student's individual learning pace and style (Gligorea et al., 2023). Nevertheless, the use of AI in education in Indonesia remains limited due to constraints in infrastructure, policy, and institutional readiness.

Apart from supporting infrastructure and policies, another major challenge is the low level of digital literacy among educators. Many lecturers do not have sufficient understanding of AI technology, both in terms of its technical use and pedagogical aspects (Afrina et al., 2024; Ng et al., 2023). Consequently, available technologies are often underutilised or ignored, and traditional learning methods continue to dominate, limiting opportunities to foster students' literacy and numeracy competencies, especially those requiring critical, analytical, and creative thinking (Rusmin et al., 2024). Moreover, current curricula and learning management systems are not yet fully integrated with technology-based approaches. Many universities lack systematic strategies to adopt and implement AI as part of daily instructional practices. Insufficient training, guidelines, and technical support further hinder effective adoption, and in some cases, technology implementation even adds administrative burdens without yielding measurable benefits to student learning outcomes (Helmiatin et al., 2024; López-Regalado et al., 2024).

As AI technology evolves, a significant opportunity emerges to leverage it in learning management. AI applications such as ChatGPT, Khanmigo, and Socratic by Google exemplify new learning tools based on natural language processing that can support student understanding (Shetye, 2024). For instance, ChatGPT can serve as an intelligent learning assistant that helps students grasp mathematical concepts interactively, adjust explanations to their comprehension levels, and provide instant feedback on problem-solving (Pepin et al., 2025; Wardat et al., 2023). However, the integration of AI in numeracy learning remains suboptimal due to limited curriculum integration, lecturers' readiness, and infrastructural capacity. Without a well-defined learning management strategy, AI runs the risk of becoming a passive trend or fostering dependency rather than promoting independent learning.

This research is therefore crucial to address the urgent need for educational reform in response to the challenges of digital transformation in the Society 5.0 era. Literacy and numeracy skills are the fundamental foundations of learning and everyday life, and their current weakness reflects deeper systemic issues in educational quality. If left unaddressed, this gap will widen the disparity between students' competencies and the demands of an increasingly complex, technology-oriented world. At the same time, AI offers a strategic opportunity to improve the quality and equity of learning through personalized, adaptive, and data-informed management. However, these benefits will not materialize without a robust and holistic management framework. From the perspective of "alternative educational thinking," AI-based learning management represents a new paradigm in educational reform, one that redefines the relationship between technology, pedagogy, and human development. It reflects a shift from traditional mechanistic models of instruction toward a transformative and human-centered educational philosophy that leverages technology as a means to enhance, rather than replace, human intelligence and creativity. Therefore, this study seeks to design an AI-based learning management strategy that integrates technological innovation with lecturer readiness, curriculum design, evaluation systems, and student learning culture to ensure meaningful and sustainable improvements in numeracy education.

The urgency of this research lies in the pressing need to reform the learning management system to be more adaptive and responsive to the challenges of the digital era while ensuring equitable improvement in education quality. In the context of globalization and rapid digital transformation, literacy and numeracy skills are not

only indicators of academic achievement but also essential competencies for thriving in an information-based society. Falling behind in these fundamental skills may widen educational disparities and hinder the development of high-quality human resources. Therefore, innovative and technology-driven learning strategies are essential. AI offers a strategic opportunity to transform the learning process to become more adaptive, efficient, and personalised. However, without an effective management framework, the potential of AI in education may not be fully realised or could even lead to symbolic adoption without real impact. This study differs from previous research on AI in numeracy learning by focusing not merely on AI-based instructional tools but on developing a comprehensive learning management system framework that integrates lecturer readiness, curriculum alignment, evaluation mechanisms, and student learning culture to ensure meaningful and sustainable adoption of AI in numeracy education. Thus, this research contributes a novel perspective by positioning AI not just as a technological instrument but as a managed, systemic innovation within higher education.

B. Method

This research uses a mixed-method approach, which is a combination of qualitative and quantitative approaches, to obtain an in-depth and comprehensive understanding of AI-based learning management strategies in improving students' numeracy literacy skills in the era of society 5.0 (Sugiyono, 2018). This research was conducted at Quality University Elementary School Teacher Education Study Programme, Medan, North Sumatra Province, from February 10 to March 10, 2025. A qualitative approach was taken through in-depth interviews with lecturers, students, and educational technology experts to explore managerial strategies, implementation, and challenges and opportunities of using AI in learning. In addition, direct observation of the learning process in the classroom was also conducted to see the interaction between lecturers, students and AI technology in the context of teaching and learning activities, especially those related to improving numeracy literacy. Meanwhile, the quantitative approach in this study was carried out through a quasi-experimental design, namely by comparing the pre-test and post-test results of numeracy literacy between two groups of PGSD Study Programme students with the experimental group following AI-based learning, and the control group following conventional learning. The experimental class totalled 32 students and the control class totalled 32 students.

The test instrument was developed based on numeracy literacy indicators in accordance with national standards. The selection of research subjects was carried out purposively, namely selecting lecture classes that have implemented AI-based learning and lecture classes that have not implemented it. The quantitative data obtained were analysed using t-test, both paired sample t-test to measure the improvement within the same group, and independent sample t-test to compare the difference in improvement between groups. In the discussion stage, qualitative and quantitative findings were integrated through a triangulation process, where qualitative data provided contextual explanations and deeper insights into the numerical results, while quantitative data validated qualitative findings, ensuring a holistic, credible, and comprehensive interpretation of how AI-based learning management strategies contribute to enhancing numeracy literacy in higher education. All participants consented voluntarily to participate in the research, and their confidentiality and anonymity were fully protected throughout the study.

C. Results and Discussion

This research focuses on AI-based learning management strategies to improve the numeracy literacy skills of Quality University PGSD students in the era of society 5.0. A qualitative approach was used to dig deeper into how lecturers and students design, experience, and assess the learning process involving AI.

1. Results

a. AI-Based Learning Management in Improving the Numeracy Literacy Skills for PGSD Students

This study found that AI-based learning management by lecturers of basic mathematics courses and educational technology lecturers in PGSD study program were conducted systemically, from the desiging stage, implementing stage, and evaluating stage. In the designing stage, the lecturers analysed the learning needs of students, selected the appropriate technology tools, developed operational standards to ensure the consistency of learning implementation. In-depth interviews were conducted with lecturers teaching basic mathematics courses, educational technology lecturers, and students in the PGSD study programme who have attended lectures with the integration of AI technology. During the interview process to find out the managerial strategies applied in the lecture process using AI, a lecturer stated:

> "We began by mapping students' learning needs. Before implementing AI in the classroom, we first identified which parts of the numeracy material were most difficult for students to understand. After that, we selected appropriate AI-based applications such as Mathway, GeoGebra AI, and occasionally used ChatGPT for conceptual discussions. We also developed a Standard Operating Procedure (SOP) for the implementation of AI-based learning to ensure that all lecturers in the team adopted a consistent strategy. In addition, we monitored students' learning outcomes automatically with the assistance of AI," (basic mathematics lecturer, personal communication, May 19, 2025).

In this case, AI is not only used as a learning tool, but also as part of the learning management system itself. In the implementation stage, the learning process in PGSD study program used AI as the Learning Management System (LMS). The integration of AI with the LMS opens up the possibility of creating a comprehensive and responsive digital learning ecosystem. The role of lecturers changes from facilitators to managers of technology-based learning processes. The classroom observation showed that the implementation of AI technology played an active role in supporting the development of students' numeracy literacy. At the beginning of the lesson, the lecturer introduced AI platforms such as ChatGPT and GeoGebra AI to facilitate students' comprehension of statistical concepts and data visualization. Students subsequently engaged in collaborative group activities, using these applications to process numerical data and generate graphical representations

The challenges are revealed in the implementation of AI-based learning management system by the sudents and lecturers. The findings reveal challenges related to users' digital readiness, limited device and internet access, lecturers' technological–pedagogical competence, inconsistent AI implementation standards, and insufficient institutional infrastructure and policy support. In the interview, students were asked about their experience of attending lectures with the help of AI technology. One of the students explained:

> "At first, it was quite confusing. However, after the lecturer explained how to use AI tools such as Wolfram Alpha and GeoGebra AI, we gradually became familiar with them. In fact, we now prefer to study independently because when we do not understand something, we can immediately ask the AI and it explains the steps clearly. However, we still need a strong internet connection and a reliable smartphone or laptop." (students A, personal communication, May 20, 2025).

This student experience illustrates a fairly common adaptation process in the use of new technology. At first, students experienced confusion due to lack of familiarity with the AI applications used. However, with guidance from lecturers and repeated

practice, students became accustomed to and even showed higher learning independence. AI is positioned as a 'learning friend' who is always ready to provide explanations whenever needed. However, technical constraints such as device access and internet connection are a challenge, especially for students who come from limited economic backgrounds or live in areas with inadequate digital infrastructure.

To gain a wider institutional perspective on the application of AI, the researcher conducted an interview with a lecturer in educational technology. The discussion centred on identifying both the challenges and opportunities associated with integrating AI into learning, considering not only classroom practices but also the development of a sustainable educational ecosystem. In reflecting on the implementation of AI within the university context, the lecturer explained:

> "The main challenges are twofold: human resource readiness and lecturer facilities. Many lecturers still face technological constraints. However, the potential is enormous. AI can detect students' learning difficulties, provide automatic feedback, and even help generate practice questions. If it is integrated with the university's Learning Management System, its impact will be maximised. Therefore, in the future, lecturers should not only serve as instructors but also as managers of learning technology." (Lecturer in Educational Technology, personal communication, May 22, 2025).

This statement makes it clear that the implementation of AI cannot be separated from the readiness of human resources, especially lecturers. Many lecturers do not have adequate technological skills, potentially hindering the optimal integration of AI.

During the evaluating process, the automatic monitoring of learning outcomes demonstrates the utilisation of AI as a diagnostic tool that supports learning decision-making in real time. The lecturer stated, "*the potential offered by AI is enormous, especially in terms of personalising learning, providing automatic feedback, and creating varied and adaptive questions.*" (Lecturer in Educational Technology, personal communication, May 22, 2025). The lecturer's statement highlights the transformative capacity of AI in the learning process. Its ability to personalize instruction suggests that students can receive materials and tasks tailored to their individual proficiency levels and learning progress. The provision of automatic feedback indicates that AI can deliver immediate corrections and explanations, enabling continuous learning without waiting for teacher intervention. Furthermore, the generation of varied and adaptive questions reflects AI's potential to adjust task difficulty based on students' performance, thereby supporting more targeted practice and deeper conceptual understanding. Collectively, these points illustrate that AI functions not merely as a

technological tool, but as a pedagogical asset capable of enhancing learning effectiveness and supporting more responsive, data-driven instructional practices.

b. The Effectiveness of Artificial AI-Based Learning Management Strategies in Improving Students' Numeracy Literacy Skills in the Era Of Society 5.0.

To examine the effectiveness of AI-based learning on students' numeracy literacy, this study employed a quantitative approach using a quasi-experimental design. Based on the results of the statistical analysis conducted in this study, the findings demonstrate that the use of AI-based learning management strategies is effective in improving students' numeracy literacy skills in the era of society 5.0.

Quantitative data were collected through numeracy literacy tests in the form of pre-test and post-test in two groups, namely the experimental class that applied AI-based learning and the control class that used conventional learning methods. Each group consisted of 32 students. Furthermore, the data were analysed using statistical tests including normality test, homogeneity test, linearity test, and independent sample t-test to determine the significance of differences in numeracy literacy improvement between the two groups.

Table 1. Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Group	Statistic	df	Sig.	Statistic	df	Sig.
Numeracy Literacy Skills	Pretest Eksperimen	.097	32	.200*	.972	32	.570
	Posttest Eksperimen	.115	32	.200*	.955	32	.205
	Pretest Kontrol	.098	32	.200*	.955	32	.200
	Posttest Kontrol	.118	32	.200*	.968	32	.456

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 1 shows that Sig. pre-test of the experimental group is 0.570 > 0.05, and Sig post-test of the experimental group is 0.205 > 0.05. In the control group, the pre-test Sig was 0.200 > 0.05, and the post-test Sig was 0.456 > 0.05. These results indicate that the normality test of the experimental and control class data is normally distributed.

Table 2. Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Numeracy Literacy Skills	Based on Mean	.356	3	124	.785
	Based on Median	.328	3	124	.805
	Based on Median and with adjusted df	.328	3	122.744	.805
	Based on trimmed mean	.373	3	124	.773

Table 2 shows the significance value (Sig.) of students' numeracy literacy skills is 0.785. Because the value of Sig. 0.785 > 0.05, the variance of student numeracy literacy data in the experimental and control groups is homogeneous.

Table 3. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest Eksperiment	32	52.4	71.3	61.313	4.7307
Posttest Eksperiment	32	71.7	89.2	82.075	4.7717
Pretest Control	32	47.9	68.8	61.244	4.8631
Posttest Control	32	61.5	80.7	71.966	5.2733
Valid N (listwise)	32				

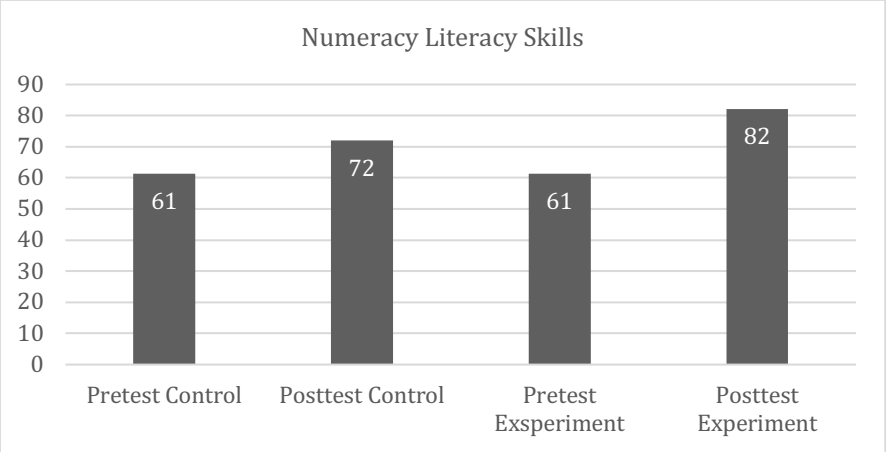

Figure 1. Average Difference in Numeracy Literacy Skills of PGSD Students at Quality University
Source: Quality University PGSD Study Program

Table 3 and Figure 1 show that the total data for the experimental group is 32 students, and the control group is 32 students. In the control group, there was an increase from the pretest score of 61.244 to 71.966 in the Posttest. This shows an increase in numeracy literacy skills even without special treatment. Meanwhile, the pretest score in the experimental group was 61.313, almost the same as the control group. However, after the experimental treatment, the posttest score increased significantly to 82.075. The much larger increase in the experimental group compared to the control group shows that the treatment in the experiment contributed effectively to the improvement of students' numeracy literacy skills. This suggests that the intervention or method applied to the experimental group had a more substantial impact on improving numeracy literacy skills than the control condition.

Table 4. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Numeracy Literacy Skills	Equal variances assumed	.191	.664	8.041	62	.000	10.1094	1.2572	7.5963	12.6225
	Equal variances not assumed			8.041	61.391	.000	10.1094	1.2572	7.5958	12.6229

Based on Table 4, the Sig (2-tailed) value is 0.000 <0.05. So as a basis for decision making on the independent sample t-test, it can be concluded that Ho is rejected and Ha is accepted. Thus, there is a significant (real) difference between the average numeracy literacy skills of students in the experimental group and the control group using AI-based learning management strategies in the Era of Society 5.0. Furthermore, the Mean Difference value is 10.1094. This value indicates the difference in the average post-test score of the experimental group and the control group, or 82.075-71.966 = 10.1094, and the difference is 7.5963 to 12.6225 (95% Confidence Interval Difference).

2. Discussion

This study reveals that AI-based learning requires a planned strategy, adequate technological readiness, and adaptation from all parties involved, both lecturers and students. Lecturers must be able to design data-based learning, students need to be trained to be able to utilise technology independently and effectively, and institutions must provide an ecosystem that supports the integration of technology in a sustainable manner. With the proper utilisation of AI, learning in higher education can be more adaptive to student needs, efficient in implementation, and able to encourage the achievement of higher numeracy competencies in the era of society 5.0.

This study show that the lecturers applied AI technology to improve students' numeracy literacy. This concept is in line with the results of research Yunianto et al. (2024) which revealed that lecturer opened the lecture with an introduction to AI platforms such as ChatGPT and GeoGebra AI to help students understand statistical concepts and data visualisation. Students then worked in groups using these applications to process data and create graphs.

Another finding of this study lies in the interaction between students and AI which is active, students ask questions directly to AI to get a quick and clear explanation of the concept of numeracy. Lecturers act as facilitators, helping with technical problems and encouraging students to remain critical of the results provided by AI. With AI, the calculation and graphing process becomes more efficient, so that learning time is more focused on discussion and analysis. However, in its implementation there are still technical problems related to devices and internet connections that are not evenly distributed among students. This concept is in line with the results of research Ningtyas & Haris (2024) and Lisnasari (2025) which revealed that the use of AI enriches the learning process by making students more independent and increasing active learning interactions, so that numeracy literacy can develop further according to the demands of the 5.0 society era.

The results also show that Artificial Intelligence (AI)-based learning management strategies have a significant contribution in improving the numeracy literacy skills of PGSD students at Quality University, especially in facing learning challenges in the era of society 5.0. Through an in-depth qualitative approach, it was found that the process of planning, implementing, and evaluating learning has utilised AI-based tools and systems in a systematic and structured manner. Lecturers teaching basic mathematics courses, for example, start the process by mapping student learning needs, selecting relevant AI applications such as Mathway, GeoGebra AI, and ChatGPT, and compiling learning operational standards to maintain consistency between lecturers. AI is not just used as a tool, but also as part of the learning management system, especially in monitoring learning outcomes automatically. This is in line with the concept of data-driven education, which places AI as a learning diagnostic tool (Edison, 2023).

The results of interviews and observations with students showed that although at first they experienced confusion using the AI application, over time students were able to adapt and even showed increased learning independence. AI is positioned as a 'learning buddy' that provides instant feedback, helps students understand numeracy concepts gradually, and strengthens their intrinsic motivation. This experience is in line with constructivistic learning principles and Vygotsky's zone of proximal development, where the role of AI resembles scaffolding that allows students to develop independently while still being guided (Malik, 2017). The use of AI also changes the role of lecturers from mere teachers to learning technology managers. One of the educational technology lecturers interviewed mentioned that the success of AI

implementation is highly dependent on the readiness of human resources and supporting infrastructure. Many lecturers still have difficulty in mastering the technology, so continuous training is an absolute necessity. However, on the other hand, the potential of AI is enormous: from the ability to detect student learning difficulties, provide automatic feedback, to help develop adaptive questions. Lecturers are also required to have competence in managing digital learning systems, especially if AI is integrated with the institution's Learning Management System (LMS).

Direct observation in classes that have implemented AI-based learning corroborates the interview findings. Students seem to actively interact with AI tools such as GeoGebra AI and ChatGPT in understanding statistics and numeracy materials. AI is used to simplify the calculation process, visualise data, and build graphs. Lecturers act as facilitators who help direct the critical use of AI and ensure that concept understanding remains the main focus. AI allows for more effective learning time, as the mechanical aspects of calculations can be outsourced to the system, while discussion and analysis time can be expanded. Nonetheless, challenges remain, especially regarding device access and internet connection. Some students from areas with inadequate digital infrastructure experienced problems in accessing the AI platform optimally. This suggests that the success of this strategy is highly dependent on institutional support in providing equitable access to technology, as well as affirmative policies for students with limited access.

Quantitatively, statistical tests showed a significant difference between the experimental group using AI-based learning and the control group using conventional methods. The average post-test score of students in the experimental group increased significantly from 61.313 to 82.075, while the control group increased from 61.244 to 71.966. The independent sample t-test confirmed that this difference was statistically significant (Sig. 0.000 < 0.05). This finding strengthens the argument that the implementation of AI-based learning management strategies not only had a positive impact subjectively (based on student and lecturer perceptions), but also objectively through an increase in numeracy literacy scores. This improvement demonstrates the effectiveness of technology-based approaches in supporting the achievement of essential numeracy competencies in the context of 21st century education (OECD, 2023).

The results of this study have important implications for the development of learning strategies in higher education, especially in the PGSD study program. *First*,

practically, the application of AI-based learning management is proven to be able to significantly improve students' numeracy literacy. This confirms that the use of AI is not just a complement to learning, but has become a necessity in responding to the demands of 21st century education. Universities need to design strategic policies to encourage the integration of AI into the curriculum, not only as a learning medium, but also as part of an adaptive and data-driven decision making learning management system. *Secondly*, the pedagogical implication is the need for a paradigm shift in the role of lecturers, from being mere deliverers of material to facilitators and managers of learning technology. This requires systematic improvement of lecturers' digital competencies, including training in the use of AI platforms, technology-based curriculum development, and the ability to structure personalised and adaptive learning. In this context, higher education institutions are required to not only provide technological devices, but also build a learning ecosystem that supports digital transformation in a sustainable manner. *Thirdly*, institutionally, the results of this study emphasise the importance of equal access to technology. The success of AI strategies in improving numeracy literacy is highly dependent on the availability of devices, internet infrastructure, and academic support for students who experience limited access. Without affirmative policies and inclusive technology investments, the digital divide may become a serious obstacle to the equitable implementation of this strategy. Therefore, the urgency to build a strong and equitable digital infrastructure is one of the main requirements in welcoming society 5.0 in education.

Theoretically, this study enriches the literature on the application of AI in primary education and future teachers. The findings reinforce that AI has great potential as a pedagogical and managerial tool in learning, especially in the development of contextual and data-based numeracy literacy. This study also provides a foundation for further studies to further explore the integration of AI in curriculum development, adaptive assessment, and improving the pedagogical competence of prospective teacher students in the digital era.

D. Conclusion

Based on the results of the research and discussion, it can be concluded that the implementation of AI-based learning management strategies has a positive impact on improving the numeracy literacy of PGSD students in the era of society 5.0. This strategy has been proven to be able to create a more adaptive, interactive, and

personalized learning process according to the learning needs of each student. Through the use of AI technology, lecturers can be more effective in designing, implementing, and evaluating numeracy learning in real-time, as well as providing fast and targeted feedback. In addition, the use of AI-supported digital platforms allows students to learn independently, explore numeracy concepts contextually, and develop critical thinking and problem-solving skills. In the context of society 5.0 which demands mastery of technology and high-level thinking skills, this strategy is one of the important innovations in responding to the challenges of higher education, especially in equipping prospective elementary school teachers with relevant and applicable numeracy competencies in the future.

Moreover, these findings also reinforce the urgency of integrating AI-based learning within the broader framework of Sustainable Development Goal 4 (Quality Education). The use of AI to enhance numeracy literacy is directly aligned with the SDG 4 agenda, which emphasizes inclusive, equitable, and high-quality education supported by digital innovation. By promoting personalized learning pathways, strengthening student autonomy, and expanding access to technology-enhanced pedagogical practices, AI-based strategies contribute to sustainable educational development and help prepare future educators who are capable of advancing transformative and future-oriented learning environments in line with global sustainability targets.

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