International Journal of Technology and Education Research

https://e-journal.citakonsultindo.or.id/index.php/IJETER

E-ISSN: 2986-0733

Integrating Artificial Intelligence In Differentiated Learning: Implications Of Teacher Competence For Student Achievement And Motivation

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Abstract

This study aims to examine the effectiveness of an Artificial Intelligence (AI)-based Differentiated Learning model in improving student achievement and academic motivation in senior high schools in Makassar. Employing a quantitative approach with a quasi-experimental design, the research involved students from several leading schools who were divided into experimental and control groups. The instruments used included achievement tests, academic motivation questions , and teacher competence observation sheets related to AI integration. The findings reveal that students in the experimental group who experienced AI-based differentiated learning achieved better posttest scores and higher academic motivation compared to those in the control group. Statistical analyzes confirmed significant differences between the two groups, while further examination indicated that teacher competence and student motivation play an essential role in shaping learning outcomes. These results highlight that the success of AI-based learning is not solely dependent on technology but is strongly influenced by teachers' ability to adapt and effectively utilize AI in differentiated learning contexts. The study underscores the importance of continuous professional development for teachers, the development of contextually relevant teaching modules, and adequate digital infrastructure support. Furthermore, this research provides empirical contributions to the advancement of adaptive and technology-based learning in Indonesia, with implications for both policy and practice.

Keyword: Differentiated Learning; Teacher Competence; Artificial Intelligence (AI); Student Learning Achievement; Academic Motivation

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INTRODUCTION

The development of digital technology, especially Artificial Intelligence (AI), has brought about a major transformation in the world of global education (Rusanti-S et al., 2025) . AI has the potential to revolutionize learning through real-time analysis of student data, automated feedback, and adaptive and personalized presentation of materials tailored to individual needs (Jarnawi et al., 2025) . One very relevant approach in using AI is Differentiated Learning, namely a learning strategy that adapts content, processes, and learning products to the diverse needs, interests, and learning styles of students (Chiu et al., 2024) . In the context of Indonesian education, the implementation of AI-based Differentiated Learning is still relatively new and faces complex challenges (Jus et al., 2025) . Although various studies have examined the benefits of AI in education in general, most have not specifically examined the integration of AI in differentiated learning that takes into account local context, teacher competency, and school infrastructure readiness (Xia et al., 2022) . Previous research has tended to be conducted in developed countries with mature education and technology ecosystems, creating a research gap on how this strategy can be implemented effectively in Indonesia's highly geographically, socially, and economically diverse education system (Syofyan et al., 2025) .

One important aspect that is often overlooked in previous research is teacher competence in integrating AI into learning practices (Christina & Panagiotidis, 2024) . Teachers play a central role in the educational process as facilitators and designers of learning strategies (Wei, 2023) . However, there are still very few studies that in-depth explore the relationship between teacher competence in using AI with student motivation and learning achievement, especially in the context of differentiated learning (Zhang & Zhang, 2024) . In fact, the success of using AI in learning does not only depend on the technology itself, but also on the teacher's ability to adapt and optimize the technology according to the characteristics of the students (Pertiwi et al., 2024) . Furthermore, although AI-based differentiated teaching modules have begun to be introduced in various teacher training sessions, particularly in the implementation of the Independent Curriculum, there is currently not much empirical evidence available regarding the effectiveness of these modules in significantly improving academic outcomes and student motivation in the classroom (Sunarto et al., 2024) . The systematic and quantitative evaluation of this AI module-based intervention is the main novelty of the study to be conducted (Iman et al., 2024) . By directly assessing the implementation of teaching modules in a school setting, this study will provide a deeper understanding of the effectiveness of a learning approach that combines technology and pedagogy simultaneously (Rijal et al., 2025) .

On the other hand, the challenges of implementing AI in education cannot be ignored.

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Some of the issues that have emerged include limited digital literacy, doubts about AI's long-term effectiveness, and teachers' concerns that their roles will be replaced by technology (Wibowo et al., 2025) . Therefore, this study is also important to explore teachers' perceptions and readiness in adopting AI, as a crucial non-technical aspect in ensuring the success of technology-based learning (Saleem et al., 2025) . Various international studies show that the use of AI in education can increase students' learning motivation and academic achievement (Anis, 2023) . However, most of these studies have been conducted overseas, with different educational system characteristics. In the unique Indonesian context, similar studies are rare, particularly those that directly examine the effectiveness of AI-based Differentiated Learning, taking into account local teacher competencies and challenges in national educational infrastructure (Chavez & Palaoag, 2024) .

As an example of practical implementation in the field, a number of schools have begun implementing differentiated learning with AI support, where teachers analyze students' initial abilities using digital platforms, compile appropriate materials, and provide feedback through AI- based systems (Xia et al., 2023) . Initial results show an increase in student motivation and learning achievement, because the material received becomes more relevant and personal (Bressane et al., 2024) . However, this phenomenon has not been studied much scientifically, so systematic and data-based research is very necessary (Elsayed et al., 2024) . Thus, this study aims to fill the literature gap by empirically examining the relationship between teacher competence, AI utilization, and the effectiveness of differentiated learning (Demartini et al., 2024) . Specifically, this study will examine (Noroozi et al., 2024) The effectiveness of a teacher competency-based differentiated learning model on student achievement, the influence of AI utilization on student academic motivation, the relationship between teacher competency in integrating AI and student learning outcomes, and teacher perceptions and readiness for implementing AI in differentiated learning.

Through the simultaneous integration of teacher competency-based pedagogical approaches and AI technology in the local Indonesian context, the novelty of this study lies in its contribution to the development of relevant, effective, and contextual adaptive learning models (Chiu et al., 2024) . The results of this study are expected to enrich academic discourse, provide recommendations for technology-based education policies, and serve as a practical reference for the development of the teaching profession in the digital era.

METHOD

This study used a quantitative approach with a quasi-experimental design to test the effectiveness of a teacher competency-based differentiated learning model and the use of

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artificial intelligence (ai) on the learning achievement and academic motivation of high school students in makassar city. this approach was chosen because it allowed for testing the effect of the treatment on the experimental group compared to a control group that did not receive the treatment, although not completely randomized. this study was conducted in six leading schools in makassar city: sma negeri 17 makassar, sma negeri 5 makassar, sma negeri 1 makassar, smas zion, smas rajawali catholic, and sma islam athira. these schools were selected because they already had adequate infrastructure and basic technological readiness to implement ai-based learning. the study took place during the even semester of the 2024/2025 academic year, encompassing the pre-exam phase, intervention implementation, and evaluation of student learning outcomes (anis, 2023) .

The study population included all 11th-grade high school students at these schools who had participated in the learning process with ai technology integration. the research sample was purposively selected from 120 students, divided into two groups: 60 in the experimental group, who participated in learning using the ai-based differentiated learning model, and 60 in the control group, who continued using conventional learning methods. this selection was based on the criteria of students actively participating in technology-based learning and the involvement of teachers who possess initial competency in ai implementation. the instruments used in the study consisted of three types. first, a learning achievement test in the form of a pretest and posttest, designed based on the national curriculum and developed with the assistance of an ai application that can adjust the difficulty level of the questions. second, an academic motivation questionnaire using a 1–5 likert scale to measure student interest, learning effort, and persistence. third, a teacher competency observation sheet focuses on teachers' ability to integrate ai into the learning process, including planning, implementation, and evaluation (elsayed et al., 2024) .

Data collection was conducted through three main methods a written test to measure student achievement, a questionnaire to measure students' academic motivation, and interviews and direct observation of teachers to assess their competency in implementing ai-based learning. each instrument underwent validation by education experts and limited trials to ensure reliability and suitability in the local context. data analysis was conducted through descriptive and inferential statistics (noroozi et al., 2024) . Descriptive statistics were used to describe the average (mean), standard deviation (sd), and distribution of data from test scores and motivation questionnaires. inferential analysis was conducted using a paired t-test to determine changes in pretest and posttest scores in the experimental group, and an independent t-test to compare the final results between the experimental and control groups. in addition, anova and multiple linear

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regression were used to determine the contribution of the independent variables (teacher competence and academic motivation) to the dependent variable (student learning achievement).

RESULTS AND DISCUSSION

The results showed that the posttest scores of students in the experimental group increased significantly compared to the control group. The average posttest score of the experimental group was 79.6, while the control group only achieved 70.3. The academic motivation of students in the experimental group also showed a higher increase, with an average score of 4.22 compared to 3.47 in the control group. The Paired t-Test confirmed that the increase in the experimental group was statistically significant ($p < 0.001$). The Independent t-Test also showed a significant difference between the two groups ($p < 0.001$) (Wei, 2023) . Furthermore, linear regression analysis showed that teacher competence in AI and academic motivation simultaneously contributed to student learning achievement with an R^2 value of 0.42, indicating a moderate effect.

Table 1. Average Posttest Scores and Academic Motivation Scores

Group	Mean Posttest Score	Academic Motivation Score
Experimental Group	79.6	4.22
Control Group	70.3	3.47

Table 1 shows that students who participated in Artificial Intelligence (AI)-based Differentiated Learning (the experimental group) achieved an average posttest score of 79.6, while the control group who participated in conventional learning only achieved 70.3. Similarly, in terms of academic motivation, the experimental group recorded an average score of 4.22, higher than the control group, which only obtained 3.47. This indicates that the AI-based learning approach is able to improve both academic outcomes and student motivation more effectively (Pertiwi et al., 2024) .

Table 2. Results of Inferential Statistical Tests

Test Type	Statistical Value	Significance (p-value)	Description
Paired t-Test (Experiment)	t = 5.62	p < 0.001	There is a significant increase

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E-ISSN: 2986-0733

Independent t-Test	t = 4.89	p < 0.001	There is a significant difference
Linear Regression	R^2 = 0.42	-	The effect is moderately significant

A paired t-test was used to examine the change in scores in the experimental group from pretest to posttest. The results showed a statistically significant increase ($p < 0.001$), indicating that AI-based learning had a significant impact on student achievement. An independent t-test was used to compare the posttest results between the experimental and control groups (Sunarto et al., 2024) . The t-value = 4.89 with $p < 0.001$ indicated that the difference between the two groups was highly significant. Linear regression analysis showed that teacher competence in AI and academic motivation jointly influenced student achievement by 42% ($R^2 = 0.42$). This means that the better the teacher competence and the higher the student motivation, the higher the academic achievement (Wibowo et al., 2025) .

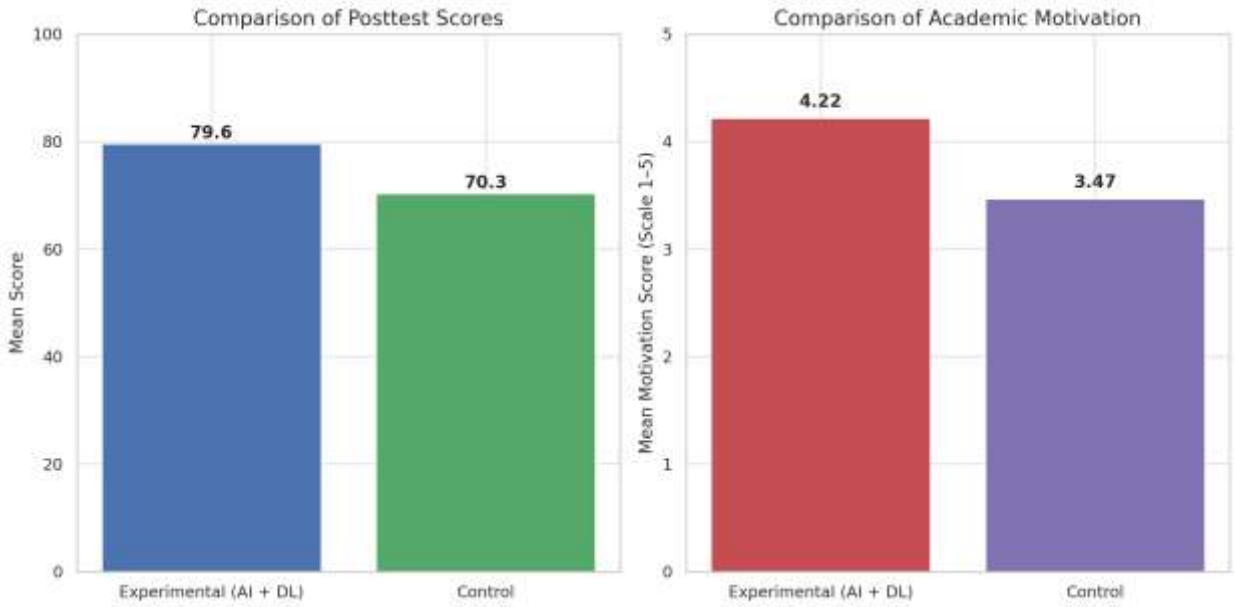


Figure 1. Comparison of Learning Outcomes and Academic Motivation between Experimental (AI + DL) and Control Groups

The results of this study statistically demonstrate that the use of Artificial Intelligence (AI)-based Differentiated Learning significantly improves student learning outcomes and academic motivation compared to conventional learning methods. Posttest scores for students in the experimental group were higher (79.6) than those in the control group (70.3), and student

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academic motivation was also higher (4.22 vs. 3.47). Theoretically, these results support the constructivist approach, where students actively construct their understanding with the help of adaptive tools such as AI. Furthermore, these findings align with the theory of self-regulated learning, as students in differentiated learning tend to be more autonomous and motivated in participating in learning activities. Another important finding is the significant influence of teacher competence on the implementation of AI (Chavez & Palaoag, 2024) . Regression analysis showed that teacher competence and student motivation together contributed 42% to student academic achievement ($R^2 = 0.42$). This suggests that the success of integrating AI into learning depends not only on the technology but also on the quality of the teachers' pedagogy (Bressane et al., 2024) .

CONCLUSION

The findings of this study demonstrate that the implementation of an Artificial Intelligence (AI)-based Differentiated Learning model is effective in enhancing both student achievement and academic motivation compared to conventional learning methods. The experimental group showed better learning outcomes and higher levels of motivation, indicating that AI-based approaches can foster not only cognitive development but also affective engagement in the learning process. Moreover, the success of AI-based learning is not solely determined by the technology itself, but also by the competence of teachers in integrating it into instructional practices. Teacher ability to design, adapt, and implement AI tools within the differentiated learning context plays a crucial role in maximizing the potential benefits of this innovation. To optimize the effectiveness of AI-based differentiated learning, several recommendations can be made. First, educational institutions should strengthen teacher training programs to ensure that teachers possess adequate pedagogical and technological skills for managing AI-assisted learning environments. Second, AI-based teaching modules should be developed in alignment with local contexts, taking into account student diversity and regional educational needs. In addition, adequate technological infrastructure must be provided by schools and supported by government policies to guarantee the smooth implementation of AI in classrooms. Further research is also encouraged to examine the broader applicability of this model across different educational levels and regional settings, while assessing its long-term impact on learning quality. Finally, the establishment of a data-driven evaluation system is essential. Such a system would enable teachers and schools to monitor student progress more accurately, provide timely feedback, and continuously improve the integration of AI in the learning process.

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