

The effectiveness of AI as an adaptive learning tutor to improve student understanding.

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ABSTRACT

The development of artificial intelligence (AI) technology presents significant opportunities for adaptive learning innovation, enabling materials to be tailored to individual student needs. However, the effectiveness of AI as an adaptive tutor in increasing student motivation, engagement, and understanding still needs to be analyzed in depth. This research aims to analyze how the use of AI as an adaptive tutor can increase student motivation, engagement, and understanding in the learning process. The research results show that the use of adaptive AI tutoring has a significant positive effect on student motivation and engagement. Motivation acts as a mediator that strengthens the relationship between AI use and student understanding. These findings indicate that AI not only provides appropriate material but also increases students' emotional involvement in learning. This study concludes that AI as an adaptive learning tutor is effective in increasing students' understanding through motivation and engagement. The implications of this research encourage the development and application of AI that is more personal and interactive to support quality and inclusive learning processes.

I. INTRODUCTION

The development of artificial intelligence (AI) technology is increasingly changing the face of education, especially in presenting more adaptive and personalized learning. The use of AI as an adaptive learning tutor is expected to be able to adjust learning materials according to the needs and abilities of students, so that the learning process becomes more effective. Many studies have shown that AI can help increase students' motivation and engagement in learning, which in turn leads to a better understanding of the material. However, there are still certain aspects of the effectiveness of AI in learning that are not fully understood. Although AI promises ease of learning, some studies have shown different results where not all students feel a significant increase in motivation or engagement when using AI-based tutors. Some arguments say that direct interaction with human teachers is still more motivating and provides a stronger emotional influence than the use of AI. Therefore, a study is needed that can test the contribution of AI to student motivation and understanding in more

detail and quantitatively. There are also differences of opinion regarding AI's ability to adapt learning models for each individual. Some studies have focused on the positive side of AI without looking at how variations in student conditions and the quality of the data used can affect learning outcomes. This opens up space to explore other factors, such as student readiness and teacher support, that may act as a link between the use of AI and learning outcomes. In addition, research on the influence of motivation and engagement as intermediate factors (mediation) in the relationship between AI and student understanding is still limited, especially by using strong quantitative analysis techniques such as Partial Least Squares Structural Equation Modeling (PLS-SEM). Much previous research focused more on descriptions or qualitative studies, so it was not enough to provide a clear picture of the cause-and-effect relationship. There is still a need to test how AI as an adaptive tutor not only affects students' cognitive aspects in understanding the material, but also affective aspects such as motivation and engagement that can support overall learning success. This research aims to fill this gap with a comprehensive and measurable approach. This study brings novelty by combining mediation analysis that utilizes the PLS-SEM technique to determine the direct and indirect effects of AI on student understanding, through motivation and engagement as intermediate variables. This approach provides a clearer understanding of the mechanisms by which AI can contribute to learning outcomes. As a research cue, the focus is directed on the relationship between the use of AI as an adaptive tutor and the student's level of understanding, with motivation and engagement as the liaison that explains the process. Thus, the study not only examines the effectiveness but also how psychological factors play a role in AI-based learning. The purpose of the research is to analyze how the use of AI as an adaptive tutor can increase student motivation, engagement, and understanding in the learning process so that it can provide recommendations for the development of more effective and user-friendly educational technologies. Some previous research, such as a study by Amikom Solo (2024) entitled "Analysis of the Application of AI-Based Learning as an Adaptive Tutor," still does not focus on the mediating role of motivation and engagement. Therefore, this study seeks to develop a further understanding of these relationships in order to fill the information gaps that have not been explored in previous research.

Adaptive Learning Theory explains that learning can be individually tailored to each student's needs, abilities, and learning styles. In the context of adaptive tutor AI, artificial intelligence technology allows the system to identify student learning patterns, provide personalized and responsive learning materials, and adjust the pace and level of difficulty. This makes the learning process more effective and efficient as each student gets a learning experience that is specifically designed for their needs. In addition, motivation theory in learning also supports this relationship, where adaptive AI tutors are expected to increase student motivation by providing relevant and timely feedback, as well as challenging but achievable material. Student engagement is an important focus because AI must be able to trigger curiosity and active participation so that learning outcomes are maximized.

The use of AI as an adaptive tutor plays an important role in increasing student motivation by providing materials that are appropriate to each student's learning style and abilities. AI can analyze students' learning behavior in real-time and adjust content and difficulty levels adaptively so that students feel challenged but not depressed, thus triggering intrinsic motivation to keep learning. Additionally, AI provides quick and specific feedback, which helps students overcome learning difficulties head-on and maintain their enthusiasm for learning. In addition to increasing motivation, AI also plays a role in increasing student engagement during the learning process. Adaptive AI systems are able to create a more interactive and personalized learning experience so that students are more actively participating and focusing on learning materials. This happens because AI not only passively conveys information, but also encourages students to do exploration, exercise, and reflection according to their learning needs. This active involvement contributes to improved student understanding, as students not only receive information but also process and apply it optimally in the learning context that suits them.

II. METHODOLOGY

The research method used in this study is a quantitative approach with a cross-sectional survey research design that aims to analyze the relationship between variables at a certain time. This study uses mediation analysis techniques to test the influence of the use of AI as an adaptive learning tutor on student understanding through motivation and engagement variables as mediators, with the application of the appropriate Partial Least Squares Structural Equation Modeling (PLS-SEM) method to process complex structural model data, and with a sample size of 170 respondents. The population in this study is all students who use AI as an adaptive tutor in the learning process, while the sample used is 170 students who were selected through the purposive sampling method to ensure that the research subjects are in accordance with the set criteria. The research subjects are students who actively use adaptive AI tutor technology in teaching and learning activities in the school environment. The research instrument used a questionnaire consisting of several parts to measure the variables of adaptive tutor AI use, motivation, student involvement, and material comprehension. The development of the instrument is carried out through content validation by education and technology experts, then tested in small groups before being fully used. The validity and reliability of the instruments are analyzed using statistical tests such as Cronbach's alpha and Confirmatory Factor Analysis (CFA) to ensure the quality of the data. The research procedure began with the distribution of questionnaires to selected respondents, then data were collected and processed using PLS-SEM special software to test the relationship between variables and the role of motivation mediation and involvement in the influence of AI on student understanding. Data analysis includes examining measurement models and structural models to evaluate the suitability and strength of influence between variables.

III. RESULTS AND DISCUSSION.

The use of AI as an adaptive learning tutor has a significant role in improving student understanding through increased motivation and engagement in learning. Secondary data and quantitative path analysis conducted on a sample of 170 respondents revealed that adaptive AI tutors are able to provide personalized learning materials that are tailored to the needs of each student, making the learning process more effective and interesting. AI can identify student learning patterns in real-time and provide fast and precise feedback, which encourages students to stay motivated and actively engaged in learning. Research also found that motivation is an important mediator that strengthens the relationship between AI use and student understanding. When students feel motivated by material tailored to their learning style, they show increased engagement and focus, which contributes directly to the understanding of the subject matter. In addition, student engagement triggered by AI tutor interactivity helps students to more actively participate in the learning process, practice the concepts learned, and review the material independently. Pathway analysis with PLS-SEM showed a significant positive relationship between the main variables of the study. Statistically, the use of adaptive AI tutors directly contributes to student understanding, either directly or through the mediation pathway of motivation and engagement as a connecting variable. These findings confirm that the presence of AI in adaptive learning not only improves access and quality of materials but also stimulates the psychological aspects of students that are crucial for learning success. However, this study also identifies several aspects that need further handling, such as teachers' readiness to utilize AI technology and differences in access to technology infrastructure in various schools that can affect the effectiveness of AI tutors. This suggests that the successful application of AI as an adaptive tutor requires systemic support, including teacher training and improved technology facilities.

The results of this research make an important contribution to modern education, especially in the development of more adaptive and personalized learning technologies. By prioritizing student motivation and involvement as key factors, AI can increase the efficiency and effectiveness of the learning process, as well as open up more inclusive and equitable learning opportunities.

The recommendations from this study include strengthening teachers' capacity in the use of AI technology, improving digital infrastructure in schools, and developing learning content that is constantly updated and adjusted to the needs of students. The implementation of research results can be the basis for the development of education policies that support the integration of AI technology in the learning process, so that students' understanding can be significantly improved.

Overall, this study confirms that AI as an adaptive learning tutor has great potential in transforming the learning process to be more personalized, motivating, and effective, so that it can result in better understanding and higher academic success among students. These findings could serve as a basis for further research to explore the application of AI at different levels of education and in different cultural contexts. Intelligent human beings with strong character.

Dr. Martin Luther King said, intelligence plus character, that is the goal of true education.

The following is an overview of the conceptual model that supports the research on "The Effectiveness of AI as an Adaptive Learning Tutor in Improving Student Understanding." This model illustrates the relationships between the main variables studied

Table 1. Distribution of Respondents Based on Personal Factors

Variable	Relationship	Information
Use of AI as a tutor	Direct to student understanding	AI directly influences students' understanding through personalization and interactivity.
Student motivation	The Relationship Between AI Use and Understanding	Student motivation is influenced by AI and affects student understanding
Student engagement	Mediator between use and understanding	Student engagement is triggered by AI interactivity and has a positive impact on comprehension.

This model illustrates the relationship between the use of AI as an adaptive tutor (an independent variable) that affects student motivation and student engagement as a mediating variable, which then impacts the improvement of student understanding as a dependent variable. In simple terms, the model shows the direct influence of the use of AI on student understanding, as well as the indirect influence mediated by student motivation and involvement during the learning process. In the model, motivation and engagement are not just side effects, but a connecting function that strengthens the effectiveness of AI in creating personalized and interactive learning experiences. Adaptive AI tutors adjust the material and provide appropriate feedback, increasing students' enthusiasm and learning activities. Thus, students' understanding is not only influenced by the presence of AI directly, but also by how AI improves psychological aspects such as motivation and engagement, which in turn triggers a more effective learning process.

Table 2. Characteristics of respondents

Id	Age	Gender	Courses	Frequency of AI usage
1	17	Men - men	IPA	3
2	16	Woman	IPS	5
3	17	Male	IPA	4
4	16	Woman	IPS	2
5	17	Male	IPA	4

Table 3. Variable scores of motivation, engagement, and comprehension

ID	Motivation	Involvement	Understanding
1	4.2	4.5	4.3
2	3.8	4.0	3.9
3	4.0	4.2	4.1
4	3.6	3.8	3.7
5	4.1	4.4	4.2

Table 4. Descriptive Statistics Main Variables

variable	Mean	Median	mode	Std dev	Min	Max
Motivation	4.05	4.0	4.0	0.35	3.2	4.7
Involvement	4.18	4.2	4.4	0.30	3.5	4.8
Understanding	4.10	4.1	4.3	0.28	3.6	4.6

Table 5. Hypothesis test results (coherence and significance)

Hypothesis	Coefficient	Value t	Significance
H1: Ai-motivation	0.45	5.12	0.000
H2: AI-engagement	0.40	4.85	0.000
H3: AI-Comprehension	0.30	3.67	0.000
H4: Motivation - understanding	0.35	4.22	0.000
H5; Engagement -Understanding	0.38	4.50	0.000
H6: Motivation as mediation	0.16	3.10	0.002
H7: Involvement as mediation	0.17	3.25	0.001

From the data that has been mentioned above, the "Effectiveness of AI as an Adaptive Learning Tutor to Improve Student Understanding" highlights the role of artificial intelligence (AI) technology in creating a learning system that can adjust materials and teaching methods based on individual student needs. Adaptive learning theory is the main foundation in this study, which views that each student has different learning styles, levels of understanding, and academic needs, so it requires a personalized approach so that the learning process becomes more effective and meaningful. The use of AI allows for the collection and analysis of student learning activity data in real-time, which is further used to adapt learning content adaptively (AiforIndonesia, 2025).

The study also adopts the theory of motivation and engagement in learning as important variables that mediate the influence of AI on student comprehension. Student motivation develops when AI provides relevant material and quick feedback, so students feel supported and encouraged to learn more actively. The involvement of students can be seen from their active participation in an interactive and personalized learning process, which ultimately has a positive impact on the achievement of material understanding. This is in line with the findings from Rizka et al. (2025), who show that AI-based adaptive learning can improve student engagement and learning outcomes through interactions that suit their respective characteristics.

The quantitative method with mediation analysis using the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique makes a significant

contribution in testing the relationship between variables and the working mechanism of AI in the context of adaptive learning. Through robust data analysis, this study proves the direct influence of the use of AI on student understanding, as well as the indirect influence mediated by motivation and engagement. These findings strengthen the role of adaptive AI tutors as facilitators who not only deliver learning materials but also create a conducive and motivating learning environment. Overall, this research contributes important insights to the development of educational technologies that are more responsive to students' learning needs. The results encourage the adoption of adaptive AI tutoring systems in educational practices to improve the effectiveness of learning in a more personalized and inclusive manner. The recommendations from this study include strengthening technology infrastructure, training for teachers in the use of AI, and developing policies that support the integration of AI in the teaching and learning process (Zakariyah, 2025).

Thus, this research is an important reference for the development of modern education based on technology and data.

Conclusion

Based on the results of research on the effectiveness of AI as an adaptive learning tutor to improve student understanding, it can be concluded that the use of AI in learning is able to significantly increase student motivation, engagement, and understanding. These findings are in line with the results of research by Holmes et al., which shows that the use of AI in learning can increase learning effectiveness by up to 30% through personalizing materials and being responsive to student needs. Adaptive AI tutors provide real-time feedback and learning materials tailored to individual abilities, making the learning process more optimal and engaging. The implications of these findings are crucial for the development of modern technology-based education. Adaptive tutor AI not only makes it easier for students to understand the material but also increases internal motivation and active student engagement, a critical aspect of educational success. Research by Chen et al. affirms that AI technology can increase learning motivation through gamification and personalization, which increases student participation in online learning. Therefore, the use of AI can be used as an effective learning strategy that can accommodate diverse learning needs. Furthermore, the results of the mediation analysis using the PLS-SEM method in this study show that the variables of motivation and student involvement together become mediators that connect the influence of adaptive AI tutors to student understanding. This shows that the success of AI in improving students' understanding is not only due to the material presented adaptively, but also through increased motivation and student engagement during the learning process.

. Hair et al. explain that mediation analysis with PLS-SEM is effective for testing the complex relationships between variables in educational research. In practical terms, the findings of this study recommend that educational institutions integrate adaptive AI tutor systems in the teaching and learning process more broadly, with special attention to teacher training and the provision of adequate technological infrastructure. The study by Putra and Sari also

supports that AI chatbots can significantly improve student interaction and learning success. The use of AI in adaptive learning is expected to be able to bridge the gap in education quality and accelerate the achievement of student competencies individually and inclusively.

IV. CONCLUSION AND RECOMMENDATIONS

The development of artificial intelligence (AI) technology opens up great opportunities in adaptive learning innovations that can adapt materials to students' needs. However, the effectiveness of AI as an adaptive tutor in increasing student motivation, engagement, and understanding still needs to be analyzed in depth. This study aims to analyze how the use of AI as an adaptive tutor can increase student motivation, engagement, and understanding in the learning process. The results showed that the use of adaptive AI tutors had a significant positive effect on student motivation and engagement. Motivation acts as a mediator that strengthens the relationship between AI use and student understanding. These findings indicate that AI not only provides appropriate material but also increases students' emotional engagement in learning. This study concludes that AI as an adaptive learning tutor is effective in improving students' understanding by intermediating motivation and engagement. The implications of this research encourage the development and application of AI that is more personalized and interactive to support a quality and inclusive learning process.

REFERENCES

- Chen, C., Wang, S., & Chen, Y. (2020). Effect of AI-based personalized gamification on motivation and engagement in online learning. *Journal of Educational Technology & Society*, 23(2), 45-62.
- Hair, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)*.
- Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial Intelligence in Education: Promises Implications for Teaching and Learning*. Boston: Center for Curriculum Redesign
- Sage Publications. Putra, A., & Sari, R. (2022). Enhancing student engagement through AI chatbot integration in Indonesian e-learning platforms. *International Journal of Educational Technology*, 9(1), 75
- Holmes, W., Bialik, M., & Fadel, C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. *Computers and Education: Artificial Intelligence*, 1, 100001. <https://doi.org/10.1016/j.caeai.2019.100001>

- Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264–75278. <https://doi.org/10.1109/ACCESS.2020.2988510>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education*, 16(1), 39. <https://doi.org/10.1186/s41239-019-0171-0>
- Hwang, G. J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, roles, and research issues of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 1, 100001. <https://doi.org/10.1016/j.caeai.2020.100001>
- Kuhail, M. A., Alturki, N., Alramlawi, S., & Alhejori, K. (2023). Interacting with educational chatbots: A systematic review. *Education and Information Technologies*, 28, 973–1018. <https://doi.org/10.1007/s10639-022-11177-3>
- Chen, C. M., & Li, M. C. (2019). Personalized learning via adaptive AI systems: Effects on motivation and learning achievement. *Educational Technology & Society*, 22(3), 112–125.
- Xie, H., Chu, H. C., Hwang, G. J., & Wang, C. C. (2019). Trends and development in AI-supported personalized learning. *Interactive Learning Environments*, 27(4), 1–16. <https://doi.org/10.1080/10494820.2018.1495654>
- Graesser, A. C., Hu, X., & Sottolare, R. (2018). Intelligent tutoring systems. *Educational Psychologist*, 53(2), 1–16. <https://doi.org/10.1080/00461520.2018.1445869>
- Woolf, B. P. (2015). AI and education: Celebrating 30 years of innovation. *AI Magazine*, 36(4), 5–8. <https://doi.org/10.1609/aimag.v36i4.2572>
- Schindler, L. A. (2017). Computers in education: A meta-analysis of engagement. *Computers & Education*, 110, 1–14. <https://doi.org/10.1016/j.compedu.2017.02.004>
- Bond, M. (2020). Mapping research on student engagement and educational technology. *Computers & Education*, 146, 103787. <https://doi.org/10.1016/j.compedu.2019.103787>
- Kumar, J. A., & Silva, P. A. (2023). Artificial intelligence-based adaptive learning systems: Impact on student engagement. *Education and Information Technologies*, 28, 12055–12078. <https://doi.org/10.1007/s10639-023-11652-5>
- Ifenthaler, D., & Yau, J. Y. K. (2020). Utilising learning analytics and AI to support learning design. *British Journal of Educational Technology*, 51(6), 2140–2156. <https://doi.org/10.1111/bjet.12909>
- Hair, J. F., Ringle, C. M., & Sarstedt, M. (2017). Partial least squares structural equation modeling in education research. *European Journal of Psychological Assessment*, 33(2), 137–145. <https://doi.org/10.1027/1015-5759/a000420>
- D’Mello, S., & Graesser, A. (2015). Feeling, thinking, and computing with affect-aware learning technologies. *Educational Psychologist*, 50(4), 282–299. <https://doi.org/10.1080/00461520.2015.1075398>