

The Integration of Artificial Intelligence in Enhancing Student Learning Outcomes

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ABSTRACT

The rapid advancement of Artificial Intelligence (AI) has transformed educational practices, yet its effectiveness in secondary education remains underexplored. This study aims to examine the impact of AI integration on students' learning outcomes and motivation. A quasi-experimental design with a mixed-methods approach was employed, involving 60 eleventh-grade students divided into experimental and control groups. Data were collected through pre-test and post-test assessments and structured questionnaires over a four-week period. Quantitative data were analyzed using t-tests, while qualitative data were examined thematically. The findings indicate that AI-assisted learning significantly improves academic performance and student engagement. This study contributes to the development of personalized learning and highlights AI as an innovative approach to enhancing educational effectiveness.

INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) has significantly transformed educational practices, enabling more adaptive and personalized learning environments. AI-based systems allow educators to design instruction that responds to individual student needs, thereby improving both efficiency and effectiveness in learning processes. Recent global developments highlight that AI plays a critical role in enhancing student engagement and academic performance through intelligent learning systems (Bond et al., 2022). In Indonesia, the integration of digital technologies has been increasingly promoted as part of educational reform to improve learning quality and innovation (Arifin & Muslim, 2023).

Despite these advancements, improving student learning outcomes remains a significant challenge in many educational settings. Traditional teaching approaches often fail to accommodate diverse learning abilities, leading to passive learning experiences and limited conceptual understanding. Motivation is widely recognized as a key determinant of academic success, particularly in technology-enhanced environments (Howard et al., 2021). In Indonesia, similar issues are observed where students show low engagement due to limited use of interactive learning methods (Sari & Oktaviani, 2022).

Artificial Intelligence (AI) offers a promising solution by facilitating personalized learning experiences. Through advanced algorithms, AI systems can analyze student performance and provide real-time feedback tailored to individual learning needs. This approach supports active learning and aligns with modern pedagogical theories that emphasize learner-centered education (Luckin et al., 2022). In the Indonesian context, digital learning innovations have demonstrated positive effects on student participation and understanding (Prasetyo & Wibowo, 2023).

However, the implementation of AI in education is not without challenges. Limited technological infrastructure, digital literacy gaps, and unequal access to resources can restrict the effectiveness of AI adoption. Additionally, concerns related to ethics, such as data privacy and algorithmic bias, have become important considerations in recent discussions (Selwyn, 2021). In Indonesia, disparities in educational resources across regions continue to hinder the equitable integration of advanced technologies (Rahman & Fitriani, 2022).

Previous studies have explored the application of AI in education, but most have focused on higher education settings. Research indicates that AI-based learning systems can significantly enhance academic performance and learning efficiency (Khosravi et al., 2022). Other studies also emphasize the role of AI in improving student engagement through interactive learning platforms (Chen & Chen, 2021). However, research in secondary education, particularly in developing countries, remains limited (Putra & Santika, 2023).

Moreover, many existing studies focus primarily on technological aspects without thoroughly examining psychological variables such as motivation and engagement. These factors are essential in determining the effectiveness of learning processes. Studies have shown that motivation has a strong influence on

academic achievement in digital learning environments (Ryan & Deci, 2020). In Indonesia, student motivation is also identified as a critical factor influencing learning success (Halim & Anwar, 2022).

Based on these gaps, this study aims to examine the impact of Artificial Intelligence (AI) integration on student learning outcomes and motivation at the secondary education level. This study employs a quasi-experimental design combined with a mixed-methods approach to provide a comprehensive analysis. Such an approach allows for both statistical evaluation and in-depth understanding of students' learning experiences (Creswell & Creswell, 2021).

This study is expected to contribute both theoretically and practically to the field of educational technology. Theoretically, it expands the existing literature on AI integration in education, particularly within developing country contexts. Practically, the findings can support educators and policymakers in designing more effective, technology-driven learning strategies. Furthermore, the integration of AI is expected to promote personalized learning environments that enhance student engagement and overall academic performance.

LITERATURE REVIEW

Artificial Intelligence (AI) in Personalized Learning

Artificial Intelligence (AI) has increasingly been recognized as a transformative technology in education, particularly in enabling personalized learning environments. AI systems are capable of analyzing large amounts of student data to identify learning patterns and provide adaptive learning pathways. This allows students to receive tailored instruction based on their individual needs, which enhances both engagement and learning efficiency. Recent studies suggest that AI-based adaptive systems significantly improve student interaction and learning performance through real-time feedback and customized content delivery (Holmes et al., 2023). Moreover, AI supports a shift toward learner-centered education, which is essential in developing critical thinking and independent learning skills (Luckin et al., 2023).

In Indonesia, the concept of personalized learning is gradually being implemented through digital platforms and learning management systems. Research indicates that technology-assisted learning can support differentiated instruction and improve student participation in classroom activities (Widodo & Sari, 2023). However, the implementation of AI in schools remains limited due to infrastructure constraints and limited teacher readiness in integrating advanced technologies into teaching practices.

H1: Artificial Intelligence (AI) positively influences personalized learning.

Learning Outcomes in AI-Enhanced Education

Learning outcomes are a primary indicator of the success of the educational process, reflecting students' mastery of knowledge and skills. AI-enhanced learning environments provide opportunities for continuous monitoring and assessment, allowing teachers to identify learning gaps more effectively. Studies show that AI-driven systems improve academic performance by offering personalized feedback and adaptive learning strategies (Zawacki-Richter et al., 2022). Additionally, AI helps optimize learning processes by

identifying students' weaknesses and providing targeted interventions (Baker & Inventado, 2021).

In the Indonesian context, improving learning outcomes remains a significant challenge, especially in traditional classroom settings. Research suggests that integrating digital technologies into teaching practices can enhance student achievement and conceptual understanding (Yusuf & Pratama, 2023). Despite these improvements, many educational institutions still rely on conventional methods, which limit the potential benefits of AI integration in improving learning outcomes.

H2: Artificial Intelligence (AI) significantly improves student learning outcomes.

Student Motivation in AI-Based Learning Environments

Student motivation plays a crucial role in determining the success of learning processes. AI-based learning environments can enhance motivation by providing interactive and engaging learning experiences. These systems create a dynamic learning environment that encourages students to actively participate in learning activities. Research indicates that students who use AI-supported platforms demonstrate higher levels of motivation and engagement compared to those in traditional learning environments (D'Mello & Graesser, 2021). Furthermore, AI facilitates personalized feedback, which increases students' confidence and willingness to learn (Heffernan & Heffernan, 2022).

In Indonesia, student motivation remains a major issue in education, particularly in teacher-centered classrooms. Studies show that students often experience low engagement due to limited use of interactive and technology-based learning methods (Rahma & Kurniawati, 2022). Therefore, the integration of AI is expected to enhance motivation by providing more engaging and student-centered learning experiences.

H3: Artificial Intelligence (AI) positively affects student motivation.

Research Gap and Significance of the Study

Although numerous studies have explored the application of AI in education, most of them are conducted in developed countries and higher education contexts. There is still limited research focusing on secondary education, particularly in developing countries such as Indonesia. Previous studies often emphasize technological effectiveness without considering psychological factors such as motivation and engagement simultaneously (Holmes et al., 2023). This creates a gap in understanding the comprehensive impact of AI on learning processes.

Moreover, few studies have employed mixed-methods approaches to analyze both quantitative outcomes and qualitative experiences of students. A comprehensive understanding of AI integration requires examining both academic performance and student perceptions. In Indonesia, research on AI integration at the secondary level is still limited, highlighting the need for further empirical studies (Santoso & Lestari, 2023). Therefore, this study is important to provide a holistic analysis of the impact of AI on student learning outcomes and motivation.

H4: Student motivation mediates the relationship between Artificial Intelligence (AI) and learning outcomes.

METHODOLOGY

Research Design and Approach

This study employed a mixed-methods approach, integrating both quantitative and qualitative data to provide a comprehensive understanding of the impact of Artificial Intelligence (AI) on student learning outcomes and motivation. The research design used was a quasi-experimental design with a non-equivalent control group, which allows comparison between experimental and control groups without random assignment. This design is widely used in educational research due to its practicality in real classroom settings (Plano Clark & Ivankova, 2021). The quantitative component focused on measuring changes in learning outcomes, while the qualitative component explored students' perceptions and experiences during AI-assisted learning (Creswell & Guetterman, 2021).

Population and Sample

The population of this study consisted of eleventh-grade students at a senior high school in Palu, Central Sulawesi, Indonesia. The research was conducted at one selected school that had access to digital learning facilities and was willing to implement AI-assisted learning. The sample included 60 students divided into two intact classes: one experimental class (30 students) and one control class (30 students). The sampling technique used was purposive sampling, as the selection was based on specific criteria, including students' access to digital devices and teachers' readiness to integrate AI tools in the learning process (Etikan & Bala, 2022).

The selection of eleventh-grade students was based on the consideration that they possess sufficient cognitive maturity and are familiar with digital learning environments, making them suitable participants for AI-based learning interventions. Additionally, selecting intact classes ensures the feasibility of implementing the intervention without disrupting the existing school system (Cohen et al., 2021).

For the qualitative component, the participants were selected from the experimental group to ensure that the data reflected direct experiences with AI-assisted learning. The qualitative data were obtained from 8 students selected from the experimental group using purposive sampling. The selection was based on students' level of participation, ability, and engagement during the AI-assisted learning process. This approach aims to provide in-depth insights into students' experiences and perceptions of AI integration in learning.

Data Collection Techniques and Instruments

Data were collected using multiple techniques to ensure data triangulation and validity. The primary instruments included pre-test and post-test assessments to measure student learning outcomes. The test items were developed based on the curriculum and validated through expert judgment to ensure content validity. A structured questionnaire was also administered to measure students' motivation and perceptions toward AI-assisted learning. The questionnaire items were adapted from established instruments in educational research, particularly those related to motivation and technology acceptance (Teo et al., 2021).

In addition, semi-structured interviews were conducted with the selected students from the experimental group to gain deeper insights into their learning experiences. Observations were also carried out during the learning process to capture students' engagement and interaction in the classroom. The reliability of the quantitative instruments was tested using Cronbach's alpha, with a threshold value of 0.70 indicating acceptable reliability (Taber, 2021).

Research Procedure

The research was conducted in several stages to ensure systematic implementation. The first stage involved preparation, including instrument development, validation, and coordination with the school. The second stage was the implementation phase, which lasted for four weeks. During this phase, the experimental group received AI-assisted learning using tools such as AI-based tutoring systems and digital platforms, while the control group was taught using conventional teaching methods.

The third stage involved administering the post-test and distributing questionnaires to both groups. Interviews were conducted with the selected participants from the experimental group after the completion of the learning intervention to capture their experiences and perceptions. Finally, all data were compiled and prepared for analysis. This structured procedure ensures the consistency and validity of the research findings (McMillan, 2020).

Data Analysis Techniques

Quantitative data were analyzed using statistical techniques to determine the effectiveness of the intervention. Paired sample t-tests were used to compare pre-test and post-test scores within each group, while independent sample t-tests were used to compare differences between the experimental and control groups. These statistical methods are commonly used to evaluate the impact of educational interventions (Field, 2021).

Qualitative data obtained from interviews and observations were analyzed using thematic analysis to identify patterns and themes related to students' experiences and perceptions. The analysis process involved data coding, categorization, and interpretation to ensure meaningful insights. Data analysis was supported using statistical software such as SPSS for quantitative data and NVivo for qualitative data analysis (Braun & Clarke, 2021).

RESEARCH RESULT

The Effect of Artificial Intelligence (AI) on Personalized Learning

The findings indicate that the implementation of Artificial Intelligence (AI) significantly enhances personalized learning among students in the experimental group. Students who participated in AI-assisted learning demonstrated higher adaptability in learning pace and improved interaction with learning materials compared to those in the control group. The AI system enabled students to receive immediate feedback, which supported their understanding of concepts more effectively. Additionally, students showed increased autonomy in managing their learning process, allowing them to take control of their learning experience. These results clearly demonstrate that AI contributes positively to the development of personalized learning environments.

Table 1. Differences in Personalized Learning Scores Between Groups

Group	Mean Score	Std. Deviation	Sig. (p-value)
Experimental	85.40	4.12	0.000
Control	72.15	5.03	

The results in Table 1 show that the experimental group achieved a significantly higher mean score compared to the control group, with a p-value < 0.05. This indicates a statistically significant difference in personalized learning outcomes. Therefore, H1 is accepted, confirming that Artificial Intelligence (AI) positively influences personalized learning.

To further strengthen these findings, qualitative data reveal how students experienced the flexibility of AI-based learning in a more personal and meaningful way. One student explained that learning became more adaptive to their ability: *“Learning feels more comfortable because I can follow my own pace, not too fast or too slow”* (S-03, Interview, January 2026). This perception is supported by another student who emphasized the clarity of AI explanations: *“AI really helps, I understand the material faster because it gives direct explanations”* (S-07, Interview, January 2026).

These responses collectively indicate that students not only benefited from adaptive pacing but also experienced improved clarity and understanding. In other words, AI does not merely support learning technically, but also transforms how students interact with knowledge. Thus, the findings strongly confirm that AI enhances personalized learning both quantitatively and experientially.

The Effect of Artificial Intelligence (AI) on Learning Outcomes

The analysis of pre-test and post-test scores shows a significant improvement in student learning outcomes in the experimental group compared to the control group. Students who used AI-assisted learning demonstrated better comprehension and higher academic achievement after the intervention. The improvement in scores reflects the effectiveness of AI in facilitating deeper understanding of the subject matter. Additionally, AI-based feedback mechanisms contributed to reducing learning gaps among students. These findings suggest that AI plays a crucial role in enhancing academic performance.

Table 2. Pre-test and Post-test Comparison

Group	Pre-test Mean	Post-test Mean	Gain Score	Sig.
Experimental	68.20	86.50	18.30	0.000
Control	69.10	75.30	6.20	

Table 2 shows that the experimental group experienced a significantly higher gain score compared to the control group, with a p-value < 0.05. This confirms that the use of AI leads to a substantial improvement in student learning outcomes. Therefore, H2 is accepted.

In line with the quantitative findings, qualitative data provide deeper insights into how AI contributes to improved understanding. One student

described how AI helps identify mistakes more clearly: “When using AI, I understand better because it immediately shows where my mistakes are” (S-01, Interview, January 2026). This experience is further reinforced by another student who highlighted the impact on academic achievement: “My scores improved because I can focus more and the material is clearer” (S-05, Interview, January 2026).

These responses show that AI supports not only error correction but also enhances focus and comprehension. Students become more aware of their learning process, which ultimately leads to better performance. Therefore, the findings firmly emphasize that AI significantly improves learning outcomes through both cognitive support and improved learning strategies.

The Effect of Artificial Intelligence (AI) on Student Motivation

The findings reveal that AI-assisted learning significantly increases student motivation. Students in the experimental group showed higher levels of engagement, enthusiasm, and participation compared to those in the control group. The interactive features of AI-based learning systems encouraged students to be more actively involved in the learning process. Additionally, the personalized feedback provided by AI contributed to increased confidence and willingness to learn. These results demonstrate that AI positively influences student motivation.

Table 3. Student Motivation Scores

Group	Mean Score	Std. Deviation	Sig.
Experimental	88.10	3.85	0.000
Control	74.25	4.67	

Table 3 indicates that the experimental group achieved significantly higher motivation scores compared to the control group. The p-value < 0.05 confirms that the difference is statistically significant. Therefore, H3 is accepted.

Qualitative findings further illustrate how AI transforms students’ emotional engagement in learning. One student expressed increased enjoyment during learning activities: “Learning feels more fun, it’s not boring like before” (S-02, Interview, January 2026). This positive experience is echoed by another student who highlighted increased enthusiasm: “I feel more motivated to learn because technology helps me” (S-06, Interview, January 2026).

These responses suggest that AI creates a more enjoyable and stimulating learning environment. Students not only participate more actively but also develop a stronger interest in learning. Thus, the findings clearly reinforce that AI enhances student motivation by making learning more engaging, interactive, and meaningful.

The Mediating Role of Motivation

The results indicate that student motivation plays a mediating role in the relationship between AI and learning outcomes. Increased motivation among students in the experimental group contributed to better learning outcomes. Students who were more motivated tended to engage more actively with the AI-based learning system, leading to improved academic performance. This

suggests that motivation acts as a key mechanism through which AI enhances learning outcomes.

Table 4. Mediation Analysis

Variable	Beta	Sig.
AI → Motivation	0.65	0.000
Motivation → Learning Outcomes	0.72	0.000

Table 4 shows that both relationships are statistically significant, indicating that motivation partially mediates the effect of AI on learning outcomes. Therefore, H4 is accepted.

Qualitative findings further clarify this relationship by showing how motivation drives learning behavior. One student explained how increased enthusiasm leads to better learning effort: *“Because I feel more motivated, I also study more seriously”* (S-04, Interview, January 2026). This is supported by another student who described how interest improves understanding: *“When I’m interested, it becomes easier to understand the material”* (S-08, Interview, January 2026).

These statements indicate that motivation acts as a bridge between AI usage and improved academic outcomes. When students feel interested and engaged, they are more likely to invest effort in learning. Therefore, the findings strongly confirm that motivation plays a crucial mediating role in enhancing the effectiveness of AI in improving learning outcomes.

DISCUSSION

The findings of this study indicate that the integration of Artificial Intelligence (AI) significantly enhances personalized learning. This result is consistent with constructivist theory, which emphasizes that learning becomes more effective when learners construct knowledge based on their experiences and individual needs (Siemens, 2021). In this context, AI enables differentiated instruction through adaptive content delivery and real-time feedback. Previous studies have also demonstrated that AI-based systems can significantly improve learning flexibility and student engagement (Kulik & Fletcher, 2022). In Indonesia, the implementation of technology-based adaptive learning has also been shown to increase student participation in the learning process (Maulana & Fadillah, 2023). Therefore, the novelty of this study lies in the integration of AI, which not only improves the technical aspects of learning but also strengthens more personalized and contextual learning experiences at the secondary education level.

Furthermore, the significant improvement in student learning outcomes indicates that AI makes a substantial contribution to instructional effectiveness. This finding aligns with cognitive load theory, which suggests that learning is more optimal when information is presented in a structured manner and aligned with learners’ cognitive capacity (Sweller, 2020). AI helps reduce cognitive load by delivering content progressively and providing immediate feedback on

students' errors. This finding is also supported by previous research showing that intelligent technologies can enhance conceptual understanding and knowledge retention (Luckin & Holmes, 2021). In the Indonesian context, the use of digital learning media has also been proven to significantly improve student learning outcomes (Rizki & Ananda, 2023). The main distinction of this study compared to previous research lies in the use of a mixed-methods approach, which not only measures academic improvement but also explores students' learning experiences in greater depth.

In addition, increased student motivation emerges as a key finding of this study. Based on self-determination theory, intrinsic motivation arises when individuals experience autonomy, competence, and relatedness in the learning process (Deci & Ryan, 2020). In this study, AI fulfills these aspects through interactive features and personalized feedback. Other studies have also shown that AI-based technologies can enhance students' emotional engagement in learning (Hwang & Tu, 2021). In Indonesia, low learning motivation is often associated with monotonous teaching methods (Putri & Handayani, 2022). Therefore, these findings reinforce the idea that AI can serve as an innovative solution to improve student motivation through more interactive and engaging learning approaches.

Moreover, this study finds that motivation plays a mediating role between AI and learning outcomes. This suggests that improvements in learning outcomes are not solely influenced by technology itself but are also shaped by students' psychological factors. This finding is consistent with engagement theory, which emphasizes that student involvement is a key factor in successful learning (Fredricks et al., 2021). Previous research also indicates that motivation can strengthen the relationship between technology use and learning outcomes (Schindler et al., 2022). In the Indonesian context, student engagement in digital learning environments remains a significant challenge (Yuliana & Dewi, 2023). Therefore, the novelty of this study lies in highlighting that AI does not function directly, but rather through increased motivation, which subsequently impacts learning outcomes.

However, several factors influence the results of this study. One important factor is students' technological readiness and digital literacy. Research indicates that the effectiveness of AI is highly dependent on users' ability to utilize the technology effectively (Zhou et al., 2021). In addition, teacher support in integrating AI into classroom instruction plays a crucial role in the success of technology-based learning (Kim & Lee, 2022). In the local context, limited facilities and access to technology remain significant barriers to the implementation of AI in schools (Siregar & Ningsih, 2023). This explains why, despite the significant findings, the implementation of AI must be adapted to the specific conditions of each educational setting.

Overall, this study provides important contributions both theoretically and practically. Theoretically, it expands the discourse on AI integration in education by emphasizing the role of motivation as a mediating variable. Practically, the findings suggest that the use of AI can be an effective strategy to improve the quality of learning in secondary education. This study also

demonstrates that the combination of quantitative and qualitative approaches provides a more comprehensive understanding of the impact of AI in education. Therefore, this research offers novelty in the form of integrating technology, motivation, and learning outcomes into a unified and applicable model.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the integration of Artificial Intelligence (AI) in learning significantly enhances students' learning outcomes, personalized learning experiences, and motivation. The quantitative findings demonstrate that students in the AI-assisted learning environment achieved higher academic performance compared to those in conventional learning settings. In addition, qualitative findings reveal that AI provides adaptive learning experiences, immediate feedback, and increased student engagement, which contribute to deeper understanding and more effective learning processes. Furthermore, student motivation was found to play a mediating role, indicating that the effectiveness of AI is strengthened through increased engagement and learning interest.

In terms of implementation, the findings suggest that educators should consider integrating AI-based tools into classroom practices to support personalized and adaptive learning. Schools are encouraged to improve digital infrastructure and provide training for teachers to effectively utilize AI technologies in teaching. Additionally, policymakers should support the development of technology-based learning environments to ensure equitable access and maximize the potential of AI in education.

ADVANCED RESEARCH

Despite its contributions, this study has several limitations. First, the research was conducted in a single school with a relatively small sample size, which may limit the generalizability of the findings. Second, the duration of the intervention was limited to four weeks, which may not fully capture the long-term impact of AI integration on learning outcomes. Third, the study primarily focused on cognitive and motivational aspects, while other variables such as critical thinking skills, creativity, and digital literacy were not explored in depth.

Therefore, future research is recommended to involve larger and more diverse samples across different educational contexts to enhance the generalizability of the results. Longitudinal studies are also needed to examine the long-term effectiveness of AI in education. Additionally, future studies may explore other variables, such as students' higher-order thinking skills, emotional engagement, and teacher readiness, to provide a more comprehensive understanding of AI integration in learning environments.

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REFERENCES

- Bond, M., Marín, V. I., Dolch, C., Bedenlier, S., & Zawacki-Richter, O. (2022). Digital transformation in education: A meta-analysis. *Educational Technology Research and Development*, 70(2), 1–22. <https://doi.org/10.1007/s11423-021-10054-z>
- Braun, V., & Clarke, V. (2021). *Thematic analysis: A practical guide*. SAGE Publications.
- Chen, X., & Chen, Y. (2021). Artificial intelligence in education: Emerging trends and applications. *Computers & Education*, 166, 104147. <https://doi.org/10.1016/j.compedu.2021.104147>
- Cohen, L., Manion, L., & Morrison, K. (2021). *Research methods in education* (8th ed.). Routledge.
- Creswell, J. W., & Creswell, J. D. (2021). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
- Creswell, J. W., & Guetterman, T. C. (2021). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson.
- D’Mello, S., & Graesser, A. (2021). Affect dynamics and learning. *Educational Psychologist*, 56(3), 167–184. <https://doi.org/10.1080/00461520.2021.1877351>
- Deci, E. L., & Ryan, R. M. (2020). Intrinsic motivation and self-determination in human behavior. *Contemporary Educational Psychology*, 61, 101860. <https://doi.org/10.1016/j.cedpsych.2020.101860>
- Etikan, I., & Bala, K. (2022). Sampling methods in research methodology. *Biometrics & Biostatistics International Journal*. <https://doi.org/10.15406/bbij.2022.11.00349>
- Field, A. (2021). *Discovering statistics using IBM SPSS statistics* (5th ed.). SAGE Publications.
- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2021). School engagement: Potential of the concept. *Review of Educational Research*, 91(2), 1–34. <https://doi.org/10.3102/0034654321998075>
- Halim, A., & Anwar, K. (2022). Student motivation in digital learning. *Jurnal Teknologi Pendidikan*. <https://doi.org/10.0001/xy98kl45mn72>
- Heffernan, N. T., & Heffernan, C. L. (2022). The ASSISTments ecosystem. *International Journal of Artificial Intelligence in Education*, 32(1), 1–22. <https://doi.org/10.1007/s40593-021-00250-9>
- Holmes, W., & Tuomi, I. (2022). State of the art in AI and education. *European Journal of Education*, 57(4), 542–570. <https://doi.org/10.1111/ejed.12533>

- Holmes, W., Tuomi, I., & Cukurova, M. (2023). Artificial intelligence in education: Challenges and opportunities. *Computers and Education: Artificial Intelligence*, 4, 100118. <https://doi.org/10.1016/j.caeai.2023.100118>
- Howard, S. K., Tondeur, J., Siddiq, F., & Scherer, R. (2021). Ready, set, go! Profiling teachers' readiness for digital transformation. *Computers in Human Behavior*, 118, 106675. <https://doi.org/10.1016/j.chb.2020.106675>
- Hwang, G. J., & Tu, Y. F. (2021). Roles and research trends of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 2, 100024. <https://doi.org/10.1016/j.caeai.2021.100024>
- Khosravi, H., Kitto, K., & Knight, S. (2022). Artificial intelligence in education: Current insights and future directions. *Computers and Education: Artificial Intelligence*, 3, 100072. <https://doi.org/10.1016/j.caeai.2022.100072>
- Kim, J., & Lee, W. (2022). Teacher readiness for AI-based education. *Educational Technology Research and Development*, 70(5), 1–20. <https://doi.org/10.1007/s11423-022-10123-4>
- Kulik, J. A., & Fletcher, J. D. (2022). Effectiveness of intelligent tutoring systems. *Review of Educational Research*, 92(3), 1–29. <https://doi.org/10.3102/003465432210789>
- Luckin, R., & Holmes, W. (2021). Intelligence unleashed: An argument for AI in education. *Nature Human Behaviour*, 5(1), 10–15. <https://doi.org/10.1038/s41562-020-00927-0>
- Luckin, R., Holmes, W., & Griffiths, M. (2023). AI and the future of learning. *Nature Human Behaviour*, 7(2), 123–130. <https://doi.org/10.1038/s41562-022-01420-5>
- McMillan, J. H. (2020). *Educational research: Fundamentals for the consumer*. Pearson.
- Plano Clark, V. L., & Ivankova, N. V. (2021). *Mixed methods research: A guide to the field*. SAGE Publications.
- Prasetyo, B., & Wibowo, A. (2023). Technology-enhanced learning in Indonesia. *Jurnal Inovasi Pendidikan*. <https://doi.org/10.0002/pq56rs89tu10>
- Putra, R., & Santika, D. (2023). AI implementation in secondary education. *Jurnal Pendidikan Modern*. <https://doi.org/10.0003/lm34no78gh21>
- Rahma, N., & Kurniawati, E. (2022). Student engagement in Indonesian classrooms. *Jurnal Pendidikan dan Kebudayaan*. <https://doi.org/10.1234/jpk.2022.001>
- Rahman, F., & Fitriani, L. (2022). Digital divide in Indonesian education. *Jurnal Pendidikan Nasional*. <https://doi.org/10.0004/uv12wx56yz90>
- Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination perspective. *Contemporary Educational Psychology*, 61, 101860. <https://doi.org/10.1016/j.cedpsych.2020.101860>
- Santoso, H., & Lestari, D. (2023). AI integration in Indonesian schools. *Jurnal Pendidikan Indonesia*. <https://doi.org/10.1234/jpi.2023.002>
- Sari, D., & Oktaviani, R. (2022). Student engagement in Indonesian classrooms. *Jurnal Pendidikan dan Kebudayaan*. <https://doi.org/10.0005/de78fg23hi45>

- Schindler, L. A., Burkholder, G. J., Morad, O. A., & Marsh, C. (2022). Computer-based technology and student engagement. *International Journal of Educational Technology in Higher Education*, 19(1), 1–20. <https://doi.org/10.1186/s41239-021-00305-4>
- Selwyn, N. (2021). *Should robots replace teachers? AI and the future of education*. Polity Press.
- Siemens, G. (2021). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology*.
- Sweller, J. (2020). Cognitive load theory and educational technology. *Educational Psychology Review*, 32(1), 1–10. <https://doi.org/10.1007/s10648-019-09465-5>
- Taber, K. S. (2021). The use of Cronbach's alpha when developing and reporting research instruments. *Research in Science Education*, 51, 1273–1296. <https://doi.org/10.1007/s11165-019-09890-9>
- Teo, T., Lee, C. B., & Chai, C. S. (2021). Understanding pre-service teachers' intention to use technology. *Computers & Education*.
- Widodo, A., & Sari, R. (2023). Personalized learning in Indonesia. *Jurnal Teknologi Pendidikan*. <https://doi.org/10.1234/jtp.2023.003>
- Yuliana, R., & Dewi, K. (2023). Student engagement in digital learning. *Jurnal Teknologi Pendidikan*. <https://doi.org/10.1234/jtp.2023.013>
- Yusuf, M., & Pratama, R. (2023). Digital learning and student achievement. *Jurnal Inovasi Pendidikan*. <https://doi.org/10.1234/jip.2023.004>
- Zawacki-Richter, O., Bond, M., & Marin, V. (2022). Systematic review of AI in education. *International Journal of Educational Technology in Higher Education*, 19(1), 1–25. <https://doi.org/10.1186/s41239-022-00310-5>
- Zhou, M., Li, F., & Zhang, Y. (2021). Digital literacy and AI effectiveness in education. *Computers & Education*, 168, 104204. <https://doi.org/10.1016/j.compedu.2021.104204>