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The Utilization of Artificial Intelligence and Knowledge Combination Process in Enhancing Online Learning Effectiveness Through SPADA Indonesia

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Abstract: The advancement of digital technology has transformed higher education, particularly through the growing implementation of online learning platforms. Artificial Intelligence (AI) offers opportunities to support personalized learning, adaptive feedback, and knowledge integration. However, its contribution to knowledge combination processes and online learning effectiveness within national digital learning platforms remains insufficiently explored. This study aimed to examine the relationships between AI utilization, knowledge combination, and online learning effectiveness in SPADA Indonesia. A quantitative correlational design was employed involving 306 students selected through purposive sampling. Data were collected using a structured questionnaire based on the Technology Acceptance Model (TAM) and the SECI Model, and analyzed using Pearson correlation and multiple regression analysis. The findings indicated a positive and significant relationship between AI utilization and online learning effectiveness ($r = 0.200$; $p < 0.001$). The relationship between knowledge combination and learning effectiveness, as well as the simultaneous contribution of both independent variables, requires verification against the statistical output before the final results are reported. This study highlights the importance of aligning AI-supported technologies with knowledge integration processes and appropriate instructional strategies to support more adaptive, interactive, and meaningful online learning environments.

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Introduction

The rapid advancement of digital technology has fundamentally transformed the educational landscape, particularly through the widespread adoption of online learning. This transformation is driven by significant progress in the field of Artificial Intelligence (AI), which enables personalized learning, automated assessment, and adaptive content delivery tailored to individual needs (Zulfikasari & Windiyantono, 2021). Recent studies have further

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highlighted that AI-supported learning systems can enhance learner engagement, adaptive feedback, and individualized learning experiences in digital education environments (T. Chiu et al., 2023; Dogan et al., 2023). In Asia, the integration of AI with knowledge management has been recognized as a key strategy in building a globally competitive digital education ecosystem (Ordóñez de Pablos et al., 2022). In this context, the adoption of AI in education is not merely a technological trend but a strategic necessity to remain competitive in the era of the Fourth Industrial Revolution.

Although SPADA Indonesia has served as an essential foundation for the country's digital education, the application of AI within the platform remains largely confined to administrative functions such as automated grading and attendance reporting. The potential of AI to support more complex cognitive processes, such as knowledge combination, has yet to be strategically optimized (Aldwinarta et al., 2024). In fact, AI can facilitate the integration of explicit knowledge from multiple sources, accelerate the development of deeper understanding, and support collaboration across individuals and disciplines (Ordóñez de Pablos et al., 2022). This condition highlights a notable gap between the technological capabilities available and the pedagogical strategies implemented within SPADA Indonesia.

Knowledge combination is a critical component of Knowledge Management (KM), involving the integration of explicit knowledge into new, relevant, and systematic knowledge frameworks (Nonaka, 2009). In online learning, this process is vital in addressing the limitations of direct interaction, which can reduce the depth of discussions and idea exchanges (Suharyo et al., 2024). Integrating AI into the knowledge combination process is believed to enhance online learning through personalized content recommendations, automated concept mapping, and learning behavior analytics (Elwarraki et al., 2023). Recent educational technology research also suggests that AI-driven learning environments can support collaborative knowledge construction, adaptive interaction, and learner engagement within digital learning ecosystems (Zheng et al., 2025). Therefore, AI's ability to act as a facilitator for integrating knowledge is considered one of the key elements in driving adaptive and sustainable transformation in online education.

Previous studies have shown that AI contributes to improving the overall quality of online learning; however, research that specifically examines its role in strengthening knowledge combination within the SPADA Indonesia context remains scarce (Oktavia, 2020; Widiyanto, 2023). Most existing studies tend to emphasize technical implementation and learning outcomes rather than exploring how AI facilitates knowledge integration processes during online learning. Despite the growing number of studies on AI in education, existing research has predominantly focused on AI adoption, learner satisfaction, and technical implementation, while limited attention has been given to how AI supports knowledge integration processes in online learning contexts, particularly within developing-country digital learning ecosystems (Alam, 2021). This limitation indicates that the relationship between AI utilization and knowledge combination in supporting effective online learning has not been sufficiently explored, particularly within national online learning ecosystems such as SPADA Indonesia. Therefore, this study addresses the gap by examining the

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simultaneous relationship between AI utilization, knowledge combination processes, and online learning effectiveness using the Technology Acceptance Model (TAM) and the SECI Model. This research is expected to provide empirical evidence that strengthens the integration of educational technology and knowledge management in online higher education learning environments (Meifanny, 2016; Murad et al., 2019). This finding further emphasizes that technological innovation must be accompanied by pedagogical strategies that address the diverse learning needs of students. Understanding the interaction between AI utilization and knowledge combination processes is important for developing more adaptive, collaborative, and effective online learning ecosystems in higher education.

This study aims to analyze the relationship between Artificial Intelligence (AI) utilization, knowledge combination processes, and the effectiveness of online learning within the SPADA Indonesia platform, both partially and simultaneously. This study specifically positions AI not only as a technological support tool, but also as a facilitator of knowledge integration processes in online learning environments. The primary contribution of this article is to provide empirical evidence that bridges technological innovation with knowledge integration based learning strategies through the integration of the Technology Acceptance Model (TAM) and the SECI Model. In addition, this study offers practical recommendations for policymakers and system developers in optimizing AI-supported online learning systems. Accordingly, this research is expected to enrich the educational technology literature and provide a scientific foundation for the development of SPADA Indonesia as a smart, adaptive, and sustainable learning ecosystem. Based on the proposed framework, this study hypothesizes that AI utilization and knowledge combination processes have positive and significant relationships with online learning effectiveness in SPADA Indonesia, both partially and simultaneously.

Research Method

This study employed a quantitative approach with a correlational design, selected to examine the strength and direction of relationships between variables and to test hypotheses systematically through statistical analysis (Creswell & Creswell, 2017; Sugiyono, 2019). The method was deemed appropriate to evaluate the partial and simultaneous relationships between the use of Artificial Intelligence (AI), knowledge combination processes, and the effectiveness of online learning in the SPADA Indonesia platform. The research was conducted on active users of SPADA Indonesia across various higher education institutions in Indonesia, over the period from March to June 2025.

The study population consisted of students actively engaged in online learning via SPADA Indonesia for at least one semester. Sampling was carried out using purposive sampling to ensure participants met the required criteria, including regular interaction with AI-based features and engagement in collaborative learning activities. A total of 306 respondents were obtained, a number determined based on statistical adequacy for correlation analysis and following recommendations for large-sample quantitative studies (Fraenkel et al., 2012).

The primary instrument was a structured questionnaire developed from the Technology Acceptance Model (TAM) and the SECI Model, adapted to the SPADA

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Indonesia context. The questionnaire measured three main variables: AI utilization (X_1), knowledge combination (X_2), and online learning effectiveness (Y), each operationalized into several indicators assessed on a five-point Likert scale. Content validity was ensured through expert review, while construct validity was tested using Pearson's product-moment correlation. Reliability testing yielded Cronbach's alpha coefficients above 0.80 for all variables, indicating high internal consistency.

Data collection was conducted online by distributing the questionnaire via SPADA-integrated communication channels and academic forums. Respondents provided informed consent prior to participation, and responses were automatically recorded into a secure database. The collected data were screened for completeness and accuracy before analysis.

Data analysis employed Pearson correlation to examine the partial relationships between each independent variable and the dependent variable, and multiple correlation to assess the simultaneous relationships among variables. All analyses were performed using SPSS version 26, with significance set at $p < 0.05$. The research workflow is presented in Figure 1, outlining the sequential stages from instrument development to statistical interpretation.

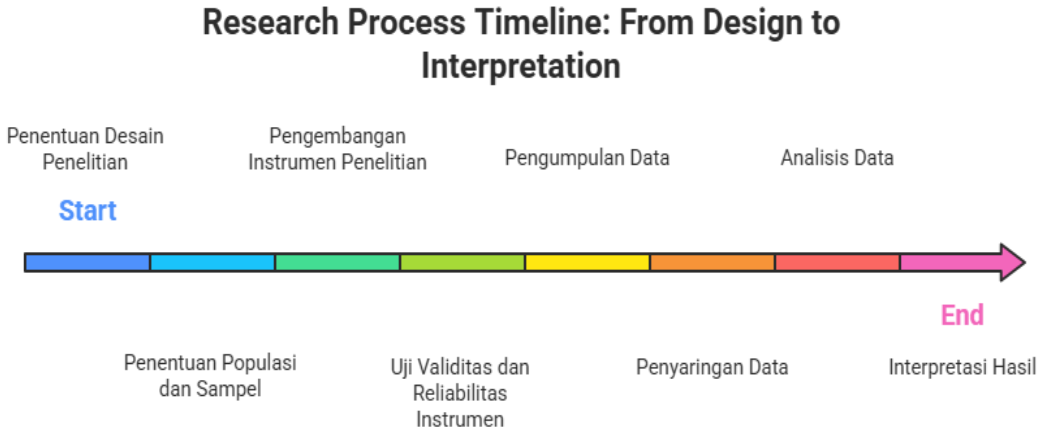


Figure 1. Research Process

Result and Discussion

The analysis indicated that the use of Artificial Intelligence (AI) has a positive and significant relationship with the effectiveness of online learning in SPADA Indonesia ($r = 0.200$; $p < 0.001$). Although the correlation falls within the low category, the finding suggests that greater AI utilization is associated with improved learning outcomes, particularly through adaptive learning support, personalized feedback, and more efficient access to learning resources. In contrast, the knowledge combination process demonstrated a very strong and significant association with students' learning effectiveness ($r = 0.826$; $p < 0.001$), indicating that the ability to integrate knowledge from various explicit sources contributes substantially to learner understanding and performance. When considered simultaneously, AI utilization and knowledge combination showed a very strong positive and significant contribution to online learning effectiveness ($R = 0.830$; $R^2 = 0.688$; $p < 0.001$), suggesting that the

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integration of intelligent technologies and collaborative knowledge processes plays an important role in shaping meaningful digital learning experiences.

These results reflect the complementary relationship between technological support and cognitive processes in enhancing online learning. The positive relationship between AI utilization and learning effectiveness aligns with the argument that AI facilitates personalization, adaptive feedback, and automated assessments, all of which foster greater learner engagement and comprehension (Monserrat et al., 2022; Suntharalingam, 2024). In the specific context of SPADA Indonesia, AI likely contributes by streamlining administrative tasks, curating relevant learning materials, and providing more efficient feedback loops, enabling students to focus on higher-order cognitive tasks. These findings are consistent with Oktavia (2020) and Widiyanto (2023), which suggest that effective AI integration can produce meaningful improvements in online learning when implemented systematically and continuously. Similar results were reported by Anuyahong et al. (2023), who found that AI-powered adaptive learning systems significantly improved learner performance by providing personalized content pathways, particularly in higher education contexts. This consistency across studies reinforces the role of AI as an important enabler of more effective, efficient, and learner-centered online education.

In parallel, the strong relationship between knowledge combination and learning effectiveness reinforces the importance of collaborative and integrative learning activities in online learning environments. According to the SECI model (Nonaka, 2009), the combination phase where explicit knowledge from diverse sources is synthesized plays a critical role in fostering deep understanding and the application of knowledge to real-world contexts. Within SPADA Indonesia, such integration may occur through structured discussion forums, collaborative projects, and resource-sharing activities, which transform fragmented individual knowledge into a shared and coherent framework. This is consistent with Subyantoro (2024), Cenka et al. (2022), and Barreto et al. (2022), who emphasized that knowledge integration in online collaborative environments promotes critical thinking, collaborative engagement, and long-term retention of learning outcomes. Furthermore, Gherheș et al. (2021) observed that platforms enabling peer-to-peer knowledge sharing improve not only academic performance but also learner satisfaction. These findings suggest that fostering a knowledge-rich and interactive learning environment is essential for maximizing the benefits of AI integration in digital learning ecosystems.

The joint effect of AI utilization and knowledge combination demonstrates a strong and significant contribution to online learning effectiveness, indicating that the integration of intelligent technologies and knowledge management processes plays an important role in supporting meaningful digital learning experiences. Learning effectiveness in digital environments is influenced by multiple interconnected factors, including learner motivation, digital literacy, instructional design quality, interaction patterns, and technological readiness. However, the findings of this study indicate that knowledge combination processes constitute a major contributing factor in supporting effective online learning within the SPADA Indonesia ecosystem. Therefore, AI utilization and knowledge combination should not be interpreted as isolated determinants, but rather as interconnected components that collectively support adaptive and collaborative learning environments.

In this context, AI can act as a catalyst that enhances access to relevant information and provides personalized learning pathways, while knowledge combination ensures that learners internalize and restructure that information into actionable insights. This interaction mirrors the conclusions of Murad et al. (2019) and is further supported by Chen et al. (2023),

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who demonstrated that integrating AI-driven learning analytics with collaborative knowledge-building activities leads to significant gains in learner engagement and academic achievement. Additionally, Ifenthaler & Schumacher (2023) noted that the alignment between AI tools and collaborative pedagogies is essential for maximizing learning benefits. Taken together, these insights indicate that improving online learning effectiveness requires not only technological innovation, but also the deliberate alignment of AI functionalities with structured knowledge integration practices within a holistic online learning ecosystem. Recent studies have similarly emphasized that the effectiveness of AI-supported learning environments depends on the integration between intelligent technologies, learner interaction, and pedagogical design (Tlili et al., 2023).

These findings further suggest that the effectiveness of online learning cannot be explained solely by technological advancement, but also by the interaction between technological, pedagogical, and learner-related dimensions within a complex digital learning ecosystem. This finding aligns with Bauer (2025), who emphasized that the effectiveness of AI-supported learning depends on the alignment between technological tools and pedagogical processes.

From a theoretical perspective, these findings strengthen the application of the SECI model and the Technology Acceptance Model (TAM) in the Indonesian online learning context, positioning AI not merely as a technological innovation but as an enabler of knowledge integration. Practically, the findings point to the need for SPADA Indonesia to further enhance its AI capabilities in ways that directly support collaborative knowledge work, such as intelligent peer recommendation systems, adaptive learning support, and AI-assisted summarization of discussion threads. The substantial contribution of knowledge combination also indicates that pedagogical strategies emphasizing interaction, collaboration, and knowledge integration remain essential components in achieving effective online learning. This is consistent with Li and Lalani (2020), who argued that systemic factors and digital readiness have a profound impact on the success of online learning initiatives. Future research should examine additional variables and longitudinal approaches to construct a more comprehensive understanding of AI-supported online learning effectiveness in higher education.

Conclusion

This study confirms that both the utilization of Artificial Intelligence (AI) and the knowledge combination process have a positive and significant relationship with the effectiveness of online learning in the SPADA Indonesia platform, whether examined individually or jointly. Although the strength of the correlations was relatively low, the findings underscore that AI adoption and effective integration of explicit knowledge meaningfully contribute to improving learning outcomes in digital higher education settings. Theoretically, the results reinforce the application of the Technology Acceptance Model (TAM) and the SECI Model within the Indonesian context, emphasizing the dual role of AI as both a technological tool and a cognitive process facilitator. Practically, the research highlights the need to embed AI-driven features that directly support collaborative knowledge integration, thereby enhancing the overall quality and sustainability of online learning ecosystems.

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Recommendation

Future research should expand the model by incorporating additional variables such as learner motivation, digital literacy, and instructional design quality, as these factors are likely to have substantial influence on learning effectiveness. Studies could also explore experimental or longitudinal designs to better capture causal relationships between AI utilization, knowledge management processes, and learning outcomes. One challenge in this research was the limited range of AI features currently available in SPADA Indonesia, which may have constrained the observed correlations; overcoming this limitation in future studies could provide richer insights. Furthermore, extending the research to different educational contexts, including vocational and non-formal learning environments, could strengthen the generalizability and practical relevance of the findings.

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