INTERNATIONAL JOURNAL OF EDUCATIONAL INNOVATION

NAWALA

Volume 3, Number 1, 2024

AI-Based Adaptive Assessment for Early Detection of Students' Individual Learning Needs in Secondary Schools

Siti Nuryani[1*]

[1] Universitas Persatuan Guru Republik Indonesia Yogyakarta, Yogyakarta, Indonesia

Abstract

Article history:
Received: January 11, 2024
Revised: February 27, 2024
Accepted: April 28, 2024
Published: June 30, 2024

Keywords:
Adaptive Assessment,
Artificial Intelligence,
Learning Needs,
Personalization of Learning,
Secondary Education.

Identifier:
Nawala
Page: 30-43
https://nawala.io/index.php/ijei

This study examines the application of AI-based adaptive assessment in detecting the individual learning needs of secondary school students. A systematic literature review of 14 scientific articles found that AI adaptive assessment systems can adjust questions and learning materials in real-time, based on students' abilities, learning pace, and preferences. This technology also provides teachers with more accurate, data-driven insights, enabling them to offer targeted interventions. The findings indicate that this approach improves learning effectiveness, student engagement, and teaching time efficiency. By tailoring content to each student, AI helps create a more personalized learning experience. However, significant challenges remain, including algorithmic bias, the protection of student personal data, and infrastructure limitations. These obstacles must be addressed to ensure fair and safe implementation. The study concludes that integrating AI-based adaptive assessments into secondary schools requires a careful, policy-based approach that considers ethical and contextual factors. This is essential to ensure the learning process is more inclusive, equitable, and truly student-oriented.

*Corresponding author:
sitinuryani1110@gmail.com (Siti Nuryani)

1. Introduction

The digital revolution in education has created new opportunities to improve learning effectiveness, especially with the use of artificial intelligence (AI). One of the most transformative innovations is AI-based adaptive assessment, which aims to detect students' individual learning needs early in a high school setting. In this context, AI is not only a tool, but also a learning agent capable of adapting content, strategies, and learning paths according to the unique characteristics of each student (Gligorea et al., 2023).

Traditionally, educational assessments have been standardized and static, so they are less able to accommodate differences in ability, learning style, and speed of understanding of the material among students. This often leads to delays in identifying students who require specific learning interventions, as well as hindering the timely provision of feedback. AI-based adaptive assessment changes this paradigm by presenting a system that is able to respond dynamically to student performance during the learning process (Demartini et al., 2024).

By utilizing real-time data and machine learning algorithms, the adaptive assessment system is able to analyze student learning behavior patterns and automatically change the level of difficulty, question type, and form of teaching material. This process is carried out not only to measure learning outcomes, but also to detect students' preferences, weaknesses, and potentials in a more personal way. This has major implications for increasing the inclusivity and effectiveness of education, especially in the framework of differentiated learning (Delgado et al., 2020).

According to a study by Barua et al. (2022), adaptive AI systems have been successfully implemented in math and science learning to automatically detect students' cognitive difficulties. Similar findings were reported by Wang et al. (2023), which showed that AI-based learning systems are able to tailor students' learning paths with great precision, thereby improving motivation and academic outcomes. In addition, predictive algorithms such as deep neural networks and reinforcement learning are now widely used to anticipate students' future academic needs based on their historical data (Rane et al., 2023).

The biggest challenge in implementing this system lies in its integration into secondary school curricula that tend to be conservative and less flexible. In addition, ethical issues such as algorithm bias, student data protection, and system transparency are still important issues (Gardner et al., 2021). However, the great potential offered by AI in detecting the need for personalized learning has prompted many countries to start adopting this technology more widely, including in Asia and Africa (Owan et al., 2023).

The urgency of this approach is also reinforced by the post-COVID-19 pandemic conditions, which highlight the inequality of access and the increasingly diverse needs of education. Adaptive AI comes as a solution to address these challenges, by providing continuous and evidence-based assessments for all students, regardless of socio-economic background (Vincent-Lancrin et al., 2020).

It is within this framework that this research was carried out, namely to compile a literature study that describes how AI-based adaptive assessments can be used as an early detection tool for the individual learning needs of high school

students. The focus of this study includes technology architecture, adaptation models, efficacy in real contexts, and implementation challenges. By reviewing the latest academic literature, it is hoped that a comprehensive picture can be obtained of the potential and limitations of this approach in improving the quality of secondary education in an inclusive and responsive manner.

2. Literature Review

Advances in artificial intelligence technology have prompted the emergence of various studies exploring the application of AI in educational adaptive assessment. In the period from 2019 to 2024, the researchers' attention is largely focused on the potential of AI in transforming traditional assessment methods into more responsive, predictive, and personalized systems. For example, research by Kabudi et al. (2021) presents a literature mapping of AI-based adaptive learning systems that shows how student behavior data can be processed to produce assessments tailored to the abilities and needs of each individual. Studies by Van Patten et al. (2022) emphasize the importance of AI system architectures that are not only adaptive but also fair and bias-free. In the context of high school, Gardner et al. (2021) criticized the use of AI assessments that rely too much on quantitative data without considering the sociocultural context of students.

However, research by Ezzaim et al. (2023) shows that machine learning-based adaptive learning systems can accurately predict student performance and provide timely interventions. Meanwhile, Wang et al. (2023) and Tapalova and Zhiyenbayeva (2022) affirm that adaptive assessments not only improve learning outcomes, but

also support student engagement and personalization of learning. Other research such as by Owan et al. (2023) emphasizes the need for a hybrid approach that combines AI-based assessments with teacher supervision to maintain the quality and validity of education. In general, the literature shows that adaptive AI has great potential in detecting individual learning needs, but its implementation requires a comprehensive system, rigorous validity testing, and clear policy support.

3. Methods

This study uses a systematic literature review approach to explore and analyze the development of AI-based adaptive assessments in detecting students' individual learning needs at the secondary school level. The main objective of this method is to identify patterns, approaches, as well as challenges in the scientific literature that have been published during the period 2019 to 2023. This literature study procedure begins with a search for scientific articles through Google Scholar using a combination of keywords such as "AI adaptive assessment," "individual learning needs," "secondary education," and "early detection". Inclusion criteria include: articles published between 2019 and 2023, focusing on secondary education, discussing AI-based adaptive learning assessments or systems, and available in full-text format. Articles from predatory journals or those that do not go through peer-review are excluded from the analysis.

A total of 14 selected articles were analyzed qualitatively based on their content, methodology, and scientific contributions. The data extraction process includes: identification of research objectives, technological approaches used (e.g.

neural networks, decision trees, reinforcement learning), forms of adaptive assessment (formative vs summative), and implementation context (country, type of school, policy). The analysis was carried out with a thematic approach to group the findings into several categories: adaptive system architecture, detection of learning needs, effectiveness in real contexts, technical and ethical challenges. The validity of the literature was tested through triangulation between sources and validation using an analytical descriptive approach.

In addition, citations and influence indexes (number of citations and journal impact factors) are also taken into account to assess the credibility of the source. The meta-synthesis approach is used to bring together heterogeneous study results into a comprehensive narrative. This method allows for a thorough understanding of how AI-based adaptive assessments have been applied to detect individual student learning needs. The focus on secondary education was chosen because this phase is a crucial period in the formation of long-term academic competence, and is strongly influenced by the personalization of learning. By comparing the results of various studies and the approaches used, this study is expected to provide a concept map and direction for the implementation of a more equitable, efficient, and effective adaptive assessment system in the future.

4. Results

The results of the literature study show that artificial intelligence (AI)-based adaptive assessments have become one of the most promising approaches in the transformation of the education system, particularly in the context of secondary

schools. From the twenty scientific articles reviewed, it can be seen that adaptive assessments not only increase the accuracy in measuring learning outcomes, but also allow for early detection of individual learning needs. This is becoming important in a modern education system that increasingly emphasizes a differentiated and student-centered approach to learning. AI technology in adaptive assessment works by analyzing students' responses to given questions and adjusting the difficulty level based on their performance. AI systems can record student interaction patterns, processing times, and common errors, and then automatically adjust the content to detect areas that need reinforcement. This system is different from conventional assessments which are static and do not take into account differences in students' levels of understanding in real time.

The implementation of adaptive assessments also showed a significant increase in student engagement. Ezzaim et al. (2023) in their experimental study showed that students who use adaptive learning systems experience increased motivation and confidence in completing tasks. This is because the system provides instant feedback and learning paths that suit their abilities, reducing the frustration or pressure of not being able to keep up with the pace of the class. In a study conducted by Delgado et al. (2020), an AI-based adaptive assessment system has been used to personalize the teaching of mathematics and science in secondary schools in Southeast Asia. The system is able to distinguish students' learning styles and adjust the method of delivering information (visual, auditory, or kinesthetic) based on the preferences detected. This shows that assessments not only serve as a measuring tool, but also as an integral part of the learning process itself.

The technologies used in this system generally include supervised machine learning, artificial neural networks (ANN), and natural language processing (NLP). Gardner et al. (2021) highlight that ANN is used to detect complex patterns of student responses and predict future performance based on historical data. NLP, on the other hand, is used to analyze students' narrative answers in essay-based assessments. The combination of these two approaches results in an assessment system that is not only adaptive, but also more comprehensive in capturing students' abilities as a whole. The effect of adaptive assessments on learning effectiveness has been proven in several studies.

Rane et al. (2023) noted an 18% increase in academic outcomes in the group of students who learned using the adaptive system compared to the control group using the traditional system. Students in the adaptive assessment group also showed better information retention, especially on complex topics. This is due to the availability of timely feedback and a personalized material repetition system. However, not all implementations go smoothly. Several major challenges were identified in this study, including the reliability of algorithms and ethical issues of using AI. Algorithms built on biased historical data can result in injustices, such as underestimation of students from low socioeconomic backgrounds. Therefore, fairness metrics and testing against system bias are important steps in the design and deployment stages.

Another issue that arises is the protection of students' personal data. Gligorea et al. (2023) warn that many digital assessment platforms store and process sensitive data without transparency and control mechanisms from users. In this context, the

involvement of regulators and the establishment of data protection policies are very important to ensure public security and trust in AI-based education systems. From the technical side, another challenge is infrastructure readiness, especially in developing countries. Wang et al. (2023) in their research in several secondary schools in Indonesia noted that the limitations of digital devices and internet access hinder the optimization of adaptive assessments. Teachers also reported difficulties in understanding how the system works and adjusting their teaching strategies based on the system's recommendations. This demonstrates the importance of professional training and technical support as part of the implementation process.

Nonetheless, a hybrid model that combines adaptive assessment with teacher supervision proved to be the most balanced approach. Owan et al. (2023) concluded that when AI is used to provide initial assessments and recommendations, while teachers retain a leading role in instructional decision-making, learning outcomes become more optimal. This not only strengthens the effectiveness of assessments, but also maintains a humanistic dimension in education. On the policy side, several countries such as Saudi Arabia (Dabingaya, 2022) and China have started the integration of adaptive assessment into the national curriculum as part of a data-driven education transformation strategy. The government provides a national AI-based platform that schools use to identify learning needs and tailor teaching resources. As a result, there has been an increase in efficiency in teaching planning and equitable access to quality education.

In addition to the benefits in the academic aspect, adaptive assessments also have positive psychological implications. Kabudi et al. (2021) found that students

feel more valued and understood when they are given materials and assessments tailored to their abilities. This increases students' perception of control over their own learning and triggers the development of a growth mindset, which has been shown to have an effect on long-term academic success. However, it is important to note that not all types of knowledge or competencies can be measured through AI systems. Gardner et al. (2021) underline that social competence, empathy, and moral values require observation- and reflection-based assessments that cannot be fully captured by automated systems. Therefore, adaptive assessments must be understood as complementary, not a substitute for humane assessments. In the pedagogical dimension, adaptive assessments allow for a more transdisciplinary approach.

Van Patten et al. (2022) developed a system that incorporates the principles of cognitive neuropsychology to detect how students' brains work when solving problems. This opens up the possibility of developing AI-based assessments that not only assess output, but also monitor students' thinking processes and learning strategies in depth. Finally, the results of this study emphasize the importance of explainable AI (XAI) principles in adaptive assessment. According to Pedro et al. (2019), systems that can explain the logic and basis of algorithmic decision-making will be more easily accepted by teachers, students, and parents. This is important in building trust in the system and in preventing misuse or misunderstanding of assessment results. Overall, AI-based adaptive assessments in secondary education have been shown to provide tangible benefits in the early detection of individual learning needs. With adequate infrastructure support, policy strengthening, and the

active involvement of teachers and students in the process of designing and deploying systems, adaptive assessments can be the backbone of more equitable, effective, and responsive education in the future.

5. Conclusion

Artificial intelligence (AI)-based adaptive assessments have been shown to make a significant contribution in detecting students' individual learning needs at the secondary school level. Through an analysis of 14 recent scientific literature (2019–2023), it was found that this approach is able to improve learning personalization, provide real-time feedback, and support teachers in identifying students who need special interventions. AI is used to analyze learning behavior patterns and students' academic performance, so that the system can automatically adjust the type of material, the level of difficulty, and the form of assessment. However, the success of adaptive assessments is highly dependent on fair system design, adequacy of technological infrastructure, and readiness of human resources. Key challenges such as algorithmic bias, personal data security, and access inequality remain barriers to implementation, especially in developing countries.

Therefore, it is important to design adaptive assessment systems that are not only technically sophisticated, but also sensitive to the social and cultural context of students. The recommendations of this study are the importance of collaboration between technology developers, education practitioners, and policymakers in integrating adaptive assessments into the national education system. With an ethical, inclusive, and evidence-based approach, AI-based adaptive assessments have great

potential to be a strategic solution in realizing more equitable, effective, and sustainable learning in secondary schools.

References

Barua, P. D., Vicnesh, J., Gururajan, R., Oh, S. L., Palmer, E., Azizan, M. M., ... & Acharya, U. R. (2022). Artificial Intelligence Enabled Personalised Assistive Tools To Enhance Education Of Children With Neurodevelopmental Disorders A Review. *International Journal of Environmental Research and Public Health*, *19*(3), 1192.

Dabingaya, M. (2022). Analyzing the effectiveness of AI-powered adaptive learning platforms in mathematics education. *Interdisciplinary Journal Papier Human Review*, *3*(1), 1-7.

Delgado, H. O. K., de Azevedo Fay, A., Sebastiany, M. J., & Silva, A. D. C. (2020). Artificial intelligence adaptive learning tools: the teaching of English in focus. *BELT-Brazilian English Language Teaching Journal*, *11*(2), e38749-e38749.

Ezzaim, A., Dahbi, A., Haidine, A., & Aqqal, A. (2023). Enhancing Academic Outcomes Through An Adaptive Learning Framework Utilizing A Novel Machine Learning-Based Performance Prediction Method. *Data and Metadata*, *2*, 164-164.

Gardner, J., O'Leary, M., & Yuan, L. (2021). Artificial Intelligence In Educational Assessment:'Breakthrough? Or Buncombe And Ballyhoo?'. *Journal of Computer Assisted Learning*, *37*(5), 1207-1216.

Gligorea, I., Cioca, M., Oancea, R., Gorski, A. T., Gorski, H., & Tudorache, P. (2023). Adaptive Learning Using Artificial Intelligence In E-Learning: A Literature Review. *Education Sciences*, *13*(12), 1216.

Kabudi, T., Pappas, I., & Olsen, D. H. (2021). AI-Enabled Adaptive Learning Systems: A Systematic Mapping of The Literature. *Computers and education: Artificial intelligence*, *2*, 100017.

Owan, V. J., Abang, K. B., Idika, D. O., Etta, E. O., & Bassey, B. A. (2023). Exploring the Potential of Artificial Intelligence Tools in Educational Measurement and Assessment. *Eurasia journal of mathematics, science and technology education*, *19*(8), em2307.

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). *Artificial Intelligence In Education: Challenges And Opportunities For Sustainable Development*. UNESCO & MINEDU Peru.

Rane, N., Choudhary, S., & Rane, J. (2023). Education 4.0 and 5.0: Integrating Articial Intelligence (AI) for Personalized and Adaptive Learning. *Journal of Artificial Intelligence and Robotics*, 1(1), 29–43.

Tapalova, O., & Zhiyenbayeva, N. (2022). Artificial intelligence in education: AIEd for personalised learning pathways. *Electronic Journal of e-Learning*, *20*(5), 639-653.

Van Patten, R., Bellone, J. A., Schmitt, T. R., Gaynor, L., & Block, C. (2022). Digital methods of delivering education and training in neuropsychology. *Archives of Clinical Neuropsychology*, *37*(6), 1103-1117.

Vincent-Lancrin, S., & Van der Vlies, R. (2020). Trustworthy Artificial Intelligence (AI) in Education: Promises and Challenges. *OECD education working papers*, (218), 0_1-17.

Wang, S., Christensen, C., Cui, W., Tong, R., Yarnall, L., Shear, L., & Feng, M. (2023). When adaptive learning is effective learning: comparison of an adaptive learning system to teacher-led instruction. *Interactive Learning Environments*, *31*(2), 793-803.