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A Comprehensive Review of AI-Based Personalized and Adaptive Learning Systems in Engineering Education

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ABSTRACT- Artificial intelligence is changing the way we learn. It is making education more personal and flexible. Artificial intelligence is helping to create learning settings that are tailored to each student. This is happening because of machine learning and other technologies. These technologies are helping to make learning more effective. This paper looks at 26 studies on artificial intelligence and learning. It looks at how artificial intelligence's being used to make learning more personal and adaptive. The paper divides these studies into four groups. It then compares them to see what works and what does not. The paper finds that artificial intelligence is helping students to learn more and get results. However, there are still some problems to solve.

For example, artificial intelligence systems need to be designed and made more scalable. They also need to be able to explain how they work. Artificial intelligence is making a difference in education. It is helping to make learning more personal and effective. The paper suggests some areas for research. It wants to make intelligence in education even better. Artificial intelligence and adaptive learning are very important. They are changing the way we learn.

KEYWORDS- Artificial Intelligence, Adaptive Learning, Personalized Education, Learning Analytics, Machine Learning.

I. INTRODUCTION

AI is changing education. It helps create teaching systems that use data [1],[2]. AI technologies like machine learning, natural language processing and learning analytics make it possible to create learning environments that adapt to each student [3]. These systems look at student data, predict how they will do and adjust the content to help them learn better [4].As schools and universities change with technology AI platforms are being used more to support teaching methods [5].

However , teaching engineering is different. It involves ideas building on previous knowledge and solving problems with skills. Traditional teaching uses the curriculum for all students no matter what they already know how fast they learn or what their abilities are [6]. This approach can make students less engaged and create gaps in their knowledge leading to academic performance [7]. Large classes, students from backgrounds and fast changes in technology make it hard to teach engineering effectively [8].

That's why personalized learning is important. When teaching is tailored to each student they can learn at their pace go back to topics, they find tough and get feedback that is just for them [9]. AI systems that adapt to each student make personalization better by tracking how well they are doing how engaged they are and how they interact with the material [10]. By adjusting the content and predicting

performance these systems help students understand better and learn on their own [11]. Personalized learning is crucial in engineering education because understanding the basics is key to doing in advanced courses and getting professional skills [12].

Even though there is research on AI-based adaptive learning systems many studies have limitations. A lot of them focus on how students do without looking at other data like behavior or long-term learning [13]. Also, many studies are done in settings, which makes it hard to use them in real-world situations [14]. There is still a lot to explore in frameworks, for engineering and a systematic review of current research is needed to see trends and find gaps [15].

II. RELATED WORK

Artificial Intelligence has really changed the way we develop learning systems in education. Many studies have looked at how we can use Artificial Intelligence to make learning personal and adaptive for students. For example, some studies use machine learning to predict how well students will do and adjust what they learn in time [1],[2].

One big review of how Artificial Intelligence's used in higher education found four main areas where Artificial Intelligence is used. Understanding students and predicting how they will do, intelligent tutoring, adaptive systems and assessment [23]. These systems mainly try to make learning by changing what students learn based on how they do.

Artificial Intelligence and learning analytics can be used together to make learning more engaging and improve test

results [3],[4]. In fields like engineering and science these systems help students learn ideas by suggesting specific things to learn and making it easier or harder based on how they do. A lot of the time these systems are only used in small groups and mostly look at test results to see how students are doing.

Some learning systems try to make learning more personal by looking at what students know and how they like to learn [5],[6]. These systems use algorithms to suggest things for students to learn based on what they know and like. While these systems make learning and students happier, we do not use all the information we could to make them even better.

Studies have shown that when we use Artificial Intelligence to make learning adaptive students do better and are more likely to stay in school [7],[8] . We need to do more research to see if this works in the long term and in different schools

A review of how Artificial Intelligence's used in online learning found that more and more schools are using personalized learning systems but we still have a lot to learn about how to make them work well [25]. Also using Artificial Intelligence to generate learning materials in real time is not something we have explored much yet.

To make learning really personal we need ways to understand what students know. A review of how we assess what students know found that we still have a lot to learn about how to do this well [26].

Even though we have made progress in using Artificial Intelligence to make learning personal we still need to develop systems that are specifically designed for fields like engineering and use methods for understanding student behavior. We need to do research to fill in the gaps in our knowledge about Artificial Intelligence and personalized learning systems in engineering education.

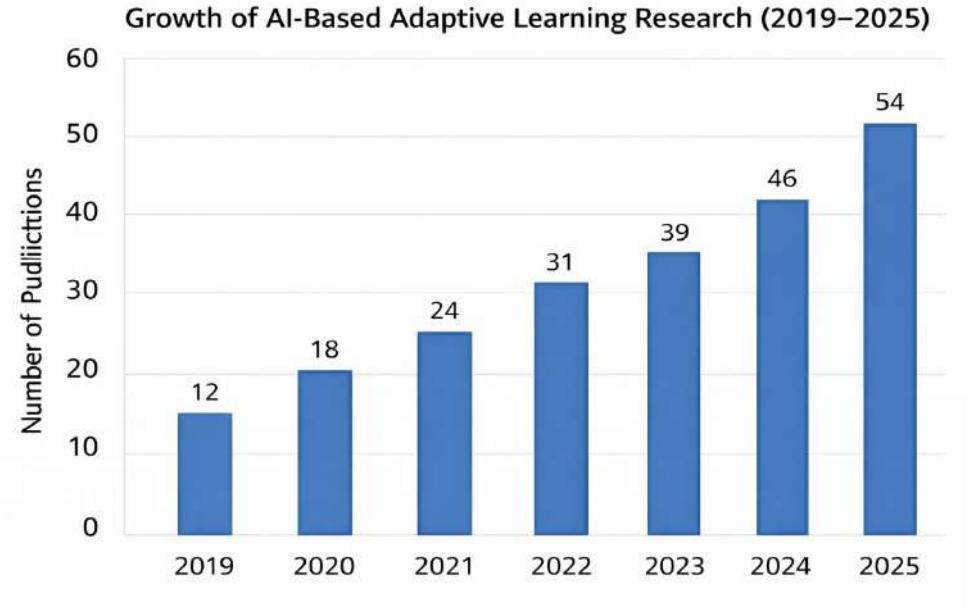

Figure 1: Growth of AI-based Adaptive Learning Research (2019–2025)

In the above Figure 1 we illustrate this upward trend. The volume of research addressing AI-based adaptive learning has expanded substantially between 2019 and 2025, reflecting growing institutional and scholarly interest. And

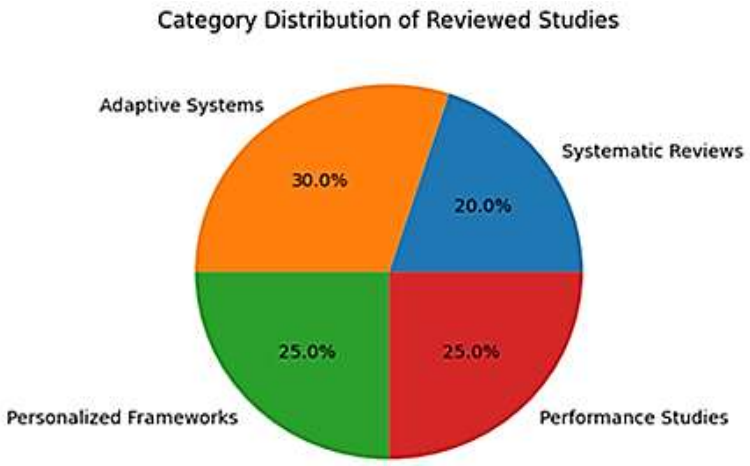

Figure 2: Category Distribution of Reviewed Studies

In the above Figure 2, we present the distribution of reviewed studies across four thematic categories. In the above Figure 2 shows that the largest proportion of research (30%) focuses on adaptive systems, highlighting a strong interest in systems that adjust to user needs and behaviors. Personalized frameworks and performance studies each account for 25%, indicating equal emphasis on customization and evaluation of system effectiveness. Systematic reviews make up the smallest share at 20%, suggesting that researchers dedicate comparatively fewer studies to summarizing existing research. Overall, this Figure 2 reflects a greater focus on developing and accessing practical solutions rather than purely reviewing prior work.

III. TECHNOLOGIES USED

Artificial Intelligence and adaptive learning systems use different computational methods to make learning better.

To understand what technologies researchers are using we looked at what Artificial Intelligence techniques they are using as shown in Figure 3.

The common approach is to use supervised machine learning, which is used to predict how students will do understand what students know and suggest things for them to learn [1],[3]. These models are primarily used for predicting student performance, classifying learner proficiency levels, and recommending personalized learning resources [4],[7].

Knowledge assessment models — including psychometric, machine learning, and deep learning approaches — serve as critical building blocks for enabling accurate learner profiling and real-time adaptation in intelligent learning environments [26].

We also use learning analytics to understand how students behave and adjust what they learn based on that [5],[6].

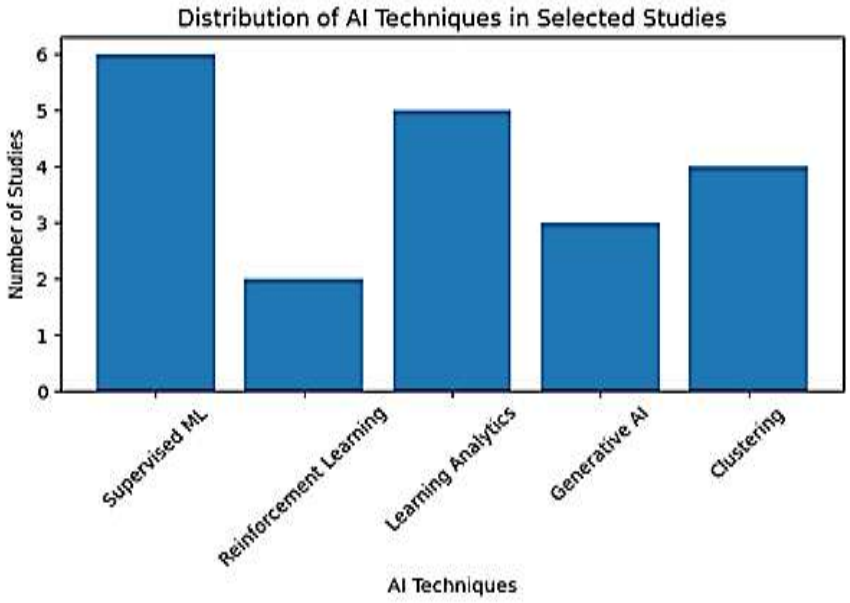

Figure 3: Distribution of AI Techniques in Selected Studies

IV. RESEARCH GAPS

The Artificial Intelligence field is really interesting. It is being used more and more in adaptive learning systems. There are still some holes in the research that need to be filled especially when it comes to teaching engineering. The Artificial Intelligence field is getting bigger. It is being used a lot in learning systems that are personalized and adaptive. There are still some big problems that need to be solved.

First studies that look at lots of research on Artificial Intelligence in education do not focus on engineering [1],[3]. They look at Artificial Intelligence in education in general. Do not look at how it is used in engineering. Some big studies found that Artificial Intelligence is used in four areas in higher education. Making profiles of students assessing students making systems that adapt to students and making smart tutoring systems[23].

More recent studies found that Artificial Intelligence is being used more and more in platforms but it is still not being used enough in engineering [25].

These techniques enable systems to monitor engagement patterns, track progress over time, and adjust instructional content dynamically based on individual learner behavior. Personalized learning frameworks use algorithms to group students based on how they behave and what they know and suggest things for them to learn based on that [24]. Some algorithms are really good at suggesting things for students to learn based on what they know and like.

We are also starting to use reinforcement learning to make adaptive learning pathways better by rewarding systems for making decisions [4]. Using Artificial Intelligence to generate learning materials in real time is not something we have explored much yet but it has a lot of potential [10],[19].

Researchers have used different Artificial Intelligence techniques, such as machine learning, learning analytics, reinforcement learning and natural language processing to support adaptive learning systems. The distribution of these techniques, in the studies we looked at is shown in Figure 3.

We need frameworks that are made for engineering not for higher education in general [4].

Second systems that use Artificial Intelligence to adapt to students often look at how well students do on quizzes and tests [5],[6] This is information but it does not tell us everything about how students learn. We know that students have learning styles and preferences but we do not use this information enough [24] We need to look at how students learn in detail including how they behave and how they interact with the learning system [8]. The Artificial Intelligence field needs to look at this in detail.

Third we need to make sure that Artificial Intelligence systems can be used by a lot of people. Many systems have only been tested with a group of students or in one class. [9],[15]. Many systems have only been tested with a group of students or in one class. Both foundational [23] and recent reviews [25] consistently highlight scalability as an unresolved challenge across AI-based educational systems.

Fourth we need to be able to make learning materials on the fly. Most systems just recommend materials that already exist than making new materials using advanced technology [7],[10]. The Artificial Intelligence field needs to get better at this.

Fifth we know that Artificial Intelligence systems can help students learn more and get grades [13],[14], most investigations are short-term and do not assess long-term knowledge retention or skills development. Robust knowledge assessment frameworks — integrating psychometric, machine learning, and deep learning models — are essential for confirming sustained learning outcomes in adaptive systems [26]. Engineering education demands sustained competency building, and longitudinal impact analyses are necessary to confirm effectiveness.

Finally, many Artificial Intelligence systems do not explain how they make decisions [11],[12]. They do not consider ethical issues. We need to make sure that these systems are transparent and fair [23]. The Artificial Intelligence field needs to get better at this.

In summary even though we know that Artificial Intelligence can help students learn there are still some problems that need to be solved. We need to make sure that Artificial Intelligence systems are designed for engineering that they look at how students learn in detail that they can be used by a lot of people that they can make new learning materials that they help students learn in the long term and that they are transparent and fair. The Artificial Intelligence field needs to work on these problems.

V. COMPARATIVE ANALYSIS OF EXISTING APPROACHES

When you look at the studies that were chosen you can see some things that keep coming up in AI-based adaptive learning systems for engineering education.

Most of the time these systems use machine learning models to figure out how well someone will do and to change the content to fit their needs [3] [7]. These systems make the instruction harder or easier.

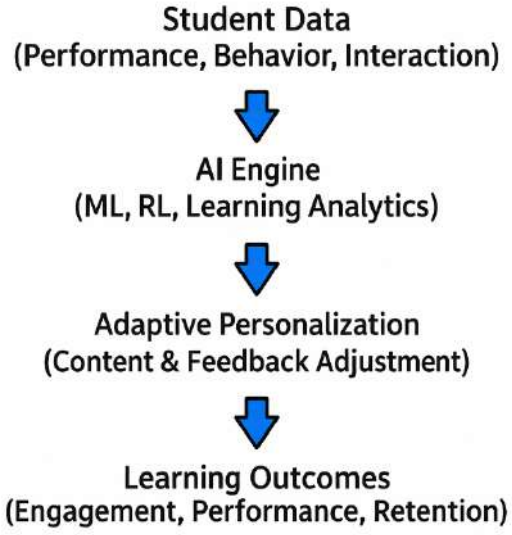

Figure 4: Conceptual Framework of AI-based Personalized Adaptive Learning System

Suggest things for the student to learn based on how they do on tests .Some systems are more complex. Use reinforcement learning to make the learning path better [4].

The ways that these systems personalize the learning experience are really different from one another. Some systems just make the content a little harder or easier [3] while others use advanced techniques like changing the order of the learning path and giving feedback that changes based on the students' needs [4] [8]. Some systems even use ways to figure out what kind of learner someone is and group them with other students who are similar [5] [6] . There are some big problems with these systems. One of the problems is that they do not work well when you try to use them with a lot of students because most of the studies were done with small groups or just one class [3] [4]. Also, the systems do not use information about how the students behave and think they mostly just look at things like test scores [5] [7].

Another thing that is missing from these systems is the ability to make content in real time using advanced natural language processing techniques. It is rare for systems to be tested over a long period of time and, in different institutions, which makes it hard to know if they will work in other places [7] [8].

Overall while AI-based adaptive systems do seem to make students more engaged and help them do better in school there is still a need for systems that're comprehensive work well with a lot of students and are specifically designed for engineering education.

In the above Figure 4 it shows what an AI-based personalized adaptive learning system might look like and in the below Table 1 we compare the eight studies that were chosen in detail .

The people who made this study looked at what other people had done and made a plan for a special kind of learning system that uses artificial intelligence to help people learn in a way that is just right for them. You can see what this plan looks like in Figure 4.

Table 1: Comparative Analysis of AI-Based Personalized Learning Systems

Study Category	AI Techniques Used	Personalization Level	Data Used	Evaluation Method	Key Findings	Major Limitations
Systematic Review [1]	ML, NLP, LA	General trends	Literature	Review synthesis	Growth of AI in education	Limited engineering focus
Systematic Review [2]	ML, ITS	Broad adaptive	Multi-source	Thematic analysis	Benefits in engagement	No scalability eval
Adaptive System [3]	Supervised ML	Content difficulty	Quiz data	Experimental	Improved performance	Small sample size
Adaptive System [4]	Reinforcement Learning	Learning path	Interaction logs	Case study	Enhanced engagement	Limited validation
Personalized Framework[5]	LA + ML	Content adaptation	Behavioral data	Comparative	Better mastery	Limited behavioral
Personalized Framework[6]	Clustering	Learner profiling	Clickstream	Quantitative	Increased satisfaction	No competency map
Performance Study[7]	Predictive ML	Performance-based	Academic records	Pre-test/post-test	Improved scores	Short-term only
Performance Study[8]	ML + Analytics	Dynamic feedback	LMS interaction	Statistical	Higher engagement	No cross-institutional

VI. FUTURE DIRECTIONS

We should make sure that the next things we do are about making learning systems that're just right for people who are learning about engineering. These systems should be made to fit with what people need to learn in school and what they need to know to get a job in the field [16],[17]. Other people have said that we need to make sure that our learning systems are based on teaching ideas and that we use artificial intelligence in a way that is good for learning [23]. We need to make systems that're just right for people who are learning about engineering and that use the things that people know about the field to help them learn.

We should also make sure that our systems can be used by a lot of people at the time and that we can use them on the internet [18]. Now we are just testing these systems with a few people or in one class and we need to see if they work well with a lot of people in different places [23],[25]. So we should make systems that can be used by a lot of people without making them less good at helping each person learn.

Artificial intelligence can also help us make things for people to learn with like practice problems and tests that are just right for each person [19]. This is different from what we have which is just giving people things that already exist. We should use language models and other artificial intelligence tools to make new things that can help people learn.

We should also make sure that we know a lot about the people who are using our systems like what they do what they know and how they learn [20]. Other people have said that we should make systems that can tell us more about the people who are using them like how they feel about learning how time they spend on it and what they know [24]. If we know all these things we can make our systems even better at helping each person learn.

We also need to make sure that we can tell how well people are learning and that we can use that information to help them [26]. We should use models and artificial intelligence tools to make systems that can see how well people are learning and that can help them learn even better.

Some studies have shown that using intelligence to help people learn can really make a difference [21]. Other studies have said that using intelligence in schools can be really helpful but we need to make sure that we do it in a way that is good for everyone [22]. We should keep studying this and see how it works over time so we can be sure that it is really helping people learn.

We should also make sure that our systems are fair, clear and good, for everyone [23]. As we use intelligence more and more in education, we need to make sure that we are using it in a way that is responsible and that we are taking care of people's private information. We should make sure that our systems are explainable and that we can trust them [25].

VII. CONCLUSION

This review looks at the research on AI-based personalized and adaptive learning systems in engineering education. Other reviews have already shown that AI applications in

education can be divided into four main areas. Profiling, prediction, intelligent tutoring and adaptive systems. But they also point out that these systems often lack strong educational foundations and do not think critically enough. Newer research confirms that AI-powered adaptive learning platforms are still showing improvements in how students engage with their work and how well they learn, no matter where they are studying.

What we found in this review is that AI technologies really do make a difference in how engaged students are, how well they do academically and how efficient instruction is. Personalized learning frameworks that use learner profiling and adaptive content recommendation strategies are particularly. They show that things like learning style and prior knowledge can be used to create customized learning paths. Also new ways of assessing knowledge. Including psychometric, machine learning and deep learning models. Are essential for building systems that are more accurate and responsive.

There are still some big challenges to overcome, like making these systems work on a large scale combining complex analytics testing them over the long term and being able to explain how they work. Engineering education in particular needs to make sure students are building their skills over time. That these systems are really making a difference in the long run, which is something that current systems do not often provide. To solve these problems, we need to create models of learner's robust frameworks for assessing knowledge ways to deploy these systems on a scale using cloud-based technology the ability to generate AI content and responsible AI governance.

In the end to really move forward with AI-powered learning in engineering education we need to shift away from general personalization models and, towards frameworks that are specifically designed for engineering education taking into account what the curriculum needs what the industry requires and how to use AI in a responsible way. If we can solve these challenges, we can create systems that are intelligent sustainable and focused on the learner and that can meet the changing needs of modern industry.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

[1] M. Murtaza *et al.*, "AI-based personalized e-learning systems: Issues, challenges, and solutions," *IEEE Access*, vol. 10, pp. 81323–81342, 2022. Available from: https://doi.org/10.1109/ACCESS.2022.3193938

[2] F. Martin, Y. Chen, R. L. Moore, and C. D. Westine, "Systematic review of adaptive learning research designs, context, strategies, and technologies from 2009 to 2018," *Educational Technology Research and Development*, vol. 68, no. 4, pp. 1903–1929, 2020. Available from: https://doi.org/10.1007/s11423-020-09793-2

[3] V. González-Calatayud, P. Prendes-Espinosa, and R. Roig-Vila, "Artificial intelligence for student assessment: A systematic review," *Applied Sciences*, vol. 11, no. 12, p. 5467, 2021. Available from: https://doi.org/10.3390/app11125467

[4] M. Imran *et al.*, "Artificial intelligence in higher education," *International Journal of Interactive Mobile Technologies*, vol. 18, no. 18, pp. 34–48, 2024. Available from: https://ieeexplore.ieee.org/abstract/document/10636217

[5] D. Aggarwal, D. Sharma, and A. B. Saxena, "Adoption of artificial intelligence (AI) for development of smart education as the future of a sustainable education system," *Journal of Artificial Intelligence, Machine Learning and Neural Networks*, vol. 36, pp. 23–28, 2023. Available from: https://doi.org/10.55529/jaimlnn.36.23.28

[6] A. Ihichr *et al.*, "A systematic review on assessment in adaptive learning: Theories, algorithms and techniques," *International Journal of Advanced Computer Science and Applications*, vol. 15, no. 7, 2024. Available from: https://tinyurl.com/fm3upc49

[7] Hariyanto, F. X. D. Kristianingsih, and R. Maharani, "Artificial intelligence in adaptive education: A systematic review of techniques for personalized learning," *Discover Education*, vol. 4, no. 1, p. 458, 2025. Available from: https://link.springer.com/article/10.1007/s44217-025-00908-6

[8] B. Tian, C. Wang, and H. Hong, "A survey of personalized adaptive learning system," in *Proc. 2nd Int. Conf. Artificial Intelligence, Computing and Information Technology (AICIT)*, Sep. 2023, pp. 1–6. Available from: https://ieeexplore.ieee.org/abstract/document/10277850

[9] A. Akavova, Z. Temirkhanova, and Z. Lorsanova, "Adaptive learning and artificial intelligence in the educational space," *E3S Web of Conferences*, vol. 451, p. 06011, 2023. Available from: https://doi.org/10.1051/e3sconf/202345106011

[10] G. Silva, G. Godwin, and O. Jayanagara, "The impact of AI on personalized learning and educational analytics," *International Transactions on Education Technology*, vol. 3, no. 1, pp. 36–46, 2024. Available from: https://doi.org/10.33050/itee.v3i1.669

[11] C. F. Mahmoud and J. T. Sørensen, "Artificial intelligence in personalized learning with a focus on current developments and future prospects," *Research and Advances in Education*, vol. 3, no. 8, pp. 25–31, 2024. Available from: https://doi.org/10.1108/IJILT-07-2024-0160

[12] R. K. Yekollu *et al.*, "AI-driven personalized learning paths: Enhancing education through adaptive systems," in *Proc. Int. Conf. Smart Data Intelligence*, Singapore: Springer, Feb. 2024, pp. 507–517. Available from: https://link.springer.com/chapter/10.1007/978-981-97-3191-6_38

[13] H. E. Sari, B. Tumanggor, and D. Efron, "Improving educational outcomes through adaptive learning systems using AI," *International Transactions on Artificial Intelligence*, vol. 3, no. 1, pp. 21–31, 2024. Available from: https://doi.org/10.33050/italic.v3i1.647

[14] T. Siswanti, N. Chai, and R. Som, "The future of adaptive learning systems in education," *Al-Hijr: Journal of Innovation in Educational Technology*, vol. 4, no. 1, 2025. Available from: https://doi.org/10.55849/jiiet.v4i1.792

[15] H. Shi, "Adaptive learning in vocational education: AI-powered content recommendations," *International Journal of High-Speed Electronics and Systems*, 2025. Available from: https://doi.org/10.1142/S0129156425408319

[16] S. Ariana *et al.*, "AI-powered adaptive e-learning to improve accessibility for diverse learner demographics," in *Proc. 4th Int. Conf. Creative Communication and Innovative Technology (ICCIT)*, Aug. 2025, pp. 1–7. Available from: https://doi.org/10.1109/ICCIT65724.2025.11167531

[17] N. T. Singh *et al.*, "AI-powered learning management system for enhanced education," in *Proc. 6th Int. Conf. Intelligent Communication Technologies and Virtual Mobile Networks (ICICV)*, Jun. 2025, pp. 460–464. Available from: https://doi.org/10.1109/ICICV64824.2025.11085707

[18] K. P. Kumar *et al.*, "An AI-powered smart learning platform integrating adaptive assessments, personalized learning paths, and performance analytics," in *Proc. ICAAIC*, 2025, pp. 1283–1288. Available from: https://doi.org/10.1109/ICAAIC64647.2025.11330782

[19] N. S. Farhah *et al.*, "Enhancing adaptive learning with generative AI," *Journal of Disability Research*, 2025. Available from: https://doi.org/10.57197/JDR-2025-0012

[20] T. K. Vashishth *et al.*, "AI-driven learning analytics for personalized feedback and assessment in higher education," in *Using Traditional Design Methods to Enhance AI-Driven Decision Making*, IGI Global, 2024, pp. 206–230. Available from: https://doi.org/10.4018/979-8-3693-0639-0.ch009

[21] J. Wu *et al.*, "Impact of AI-powered adaptive learning platforms on English reading proficiency: Evidence from structural equation modeling," *IEEE Access*, 2025. Available from: https://doi.org/10.1109/ACCESS.2025.3571055

[22] R. Sahito, F. Z. Sahito, and M. Imran, "The role of artificial intelligence (AI) in personalized learning: A case study in K-12 education," *Global Educational Studies Review*, vol. 9, no. 3, pp. 153–163, 2024. Available from: http://dx.doi.org/10.31703/gesr.2024(IX-III).15

[23] O. Zawacki-Richter *et al.*, "Systematic review of research on artificial intelligence applications in higher education—Where are the educators?" *International Journal of Educational Technology in Higher Education*, vol. 16, no. 1, p. 39, 2019. Available from: https://dialnet.unirioja.es/servlet/articulo?codigo=7288782

[24] J. Raj and V. G. Renumol, "A systematic literature review on adaptive content recommenders in personalized learning environments from 2011 to 2020," *Journal of Computers in Education*, vol. 9, no. 1, pp. 113–148, 2021. Available from: https://link.springer.com/article/10.1007/s40692-021-00199-4

[25] I. Gligorea *et al.*, "Adaptive learning using artificial intelligence in e-learning: A literature review," *Education Sciences*, vol. 13, no. 12, p. 1216, 2023. Available from: https://doi.org/10.3390/educsci13121216

[26] S. Minn, "AI-assisted knowledge assessment techniques for adaptive learning environments," *Computers and Education: Artificial Intelligence*, vol. 3, p. 100050, 2022. Available from: https://doi.org/10.1016/j.caeai.2022.100050