

Harnessing the Power of Artificial Intelligence for Adaptive Learning Systems: A Systematic Review

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Abstract: This research paper delves into the transformative potential of Adaptive Learning Systems (ALS) in revolutionizing education through the integration of Artificial Intelligence (AI). With traditional educational approaches often failing to accommodate individual learning needs, the answer to this problem is adaptive learning system which focuses on personalized content delivery, instructional methods, and assessments. Through case studies spanning various educational contexts, including various countries, higher education, and diverse cultures, we have evaluated the effectiveness of different ALS techniques in terms of different educational needs and requirements. By reviewing these techniques in terms of their features, capabilities and functionalities, we have tried to figure out, how does the use of AI in adaptive learning systems contribute to personalized learning experiences for students. The paper also highlights the key challenges and limitations associated with the integration of AI in ALS. It addresses issues like data protection, analyzes the ALS principles and investigates the ethical consideration which arises during implementation of AI in adaptive learning systems. Furthermore, it underscores the pivotal role educators' play in collaborating with AI systems to create a balanced learning environment. By providing insights into future directions, such as advancements in personalization techniques and lifelong learning, this paper contributes to understanding the complex interplay between AI and personalized education. Ultimately, the research advocates for the widespread integration of ALS as a transformative approach that has the potential to redefine education and cater to the diverse needs of learners in the digital age.

Index Terms: Adaptive Learning Systems, Personalized Education, Artificial Intelligence, Knowledge Measurement, Learning Process.

1. Introduction

To be intelligent, one must be capable of perceiving the contexts, associating that contexts with actions, and act accordingly. In spite of the fact, it's not a novel idea for machines to replicate intelligent human behavior, AI has recently become a hot topic of conversation [1]. In the process of propagating and developing personalized education, the introduction of computer-assisted instruction and learning has been crucial. In the 1950s, computer-based instruction (CBI) gained popularity, particularly in industrialized countries like the United States. However, during the beginning of the 1960s, education technologists from all over the world began to create programs to help tutors and assess pupils. The educational technology that was introduced at this time primarily incorporated behavioral psychology advances [2].

A number of years ago, before the advent of computers and other related technology, teachers and students used to carry out mechanical instruction and learning. In the 1970s, microcomputers, and subsequently personal computers, were introduced, which, according to Flamm, provided greater computing power and signaled the arrival of mass market electronic computers [3]. Based on the research of Skinner (1958), In order to identify key characteristics of

teaching machines and computer-based instruction, it would be necessary to identify the way in which materials are arranged so that students are able to make accurate responses and receive reinforcement when making them. [4].

Campbell Kelly agreed that the advent of the electronic computer, and the availability of such for a variety of entities across a wide range of economic sectors, was precipitated by the advent of personal computers in the 1970s. [5]. Individuals and non-governmental organizations can now use computers thanks to the development of personal computers. As a result of these transitions, computers proliferated in various sectors of the economy and society.

In the changing educational landscape, “the one-size-fits-all” approach to teaching and learning has proven more ineffective in meeting the different demands and learning styles of pupils. While necessary, traditional educational institutions frequently struggle to meet each student's unique needs, which has a variety of effects on students' levels of involvement, comprehension, and academic achievement [6]. Technology's quick development, especially in the area of artificial intelligence (AI), offers a possible answer to this important problem. With the frequent use of AI techniques and algorithms, adaptive learning systems (ALS) have become a transformative force in reinventing education through individualized strategies which adjust to each learner's specific characteristics and requirements [7].

Personalization of instruction is not a new concept in the classroom; rather educators have long understood how important it is to take into the abilities and interests of each and every student account. However, one of the problems with the traditional educational model has been that it was unable to provide customized instruction at such a large scale. The ALS, on the other hand, makes use of artificial intelligence to quickly gather, examine, and analyze enormous quantities of information about students. As a result of this data-driven methodology, ALS is able to modify the teaching materials, delivery techniques, and assessment plans to meet the specific needs of every individual student based on the results of the data analysis [8]. The combination of AI with personalized education corresponds with the digital era's emphasis on customization and responsiveness, allowing education to advance outside of the physical limitations of the classroom [9].

Even when technology plays a critical role in delivering individualized content, the knowledge and direction of educators are still essential for fostering critical thinking, fostering emotional intelligence, and facilitating meaningful interactions within the learning process. This partnership between AI and educators aims to provide children with a balanced, comprehensive education that will enable them to succeed academically and acquire critical life skills. [10].

Traditional education methods frequently face difficulties in catering to the learning requirements of students, leading to a demand for adaptive learning systems (ALS). These platforms aim to overcome this obstacle by focusing on tailored content delivery teaching approaches and evaluations. These systems are designed to address this challenge by emphasizing personalized content delivery, instructional methods, and assessments. In our research, we have conducted case studies that span a wide range of educational contexts, including different countries, higher education institutions, and diverse cultural backgrounds. By analyzing these studies, we have evaluated the effectiveness of various ALS techniques in relation to the distinct educational needs and requirements encountered in these contexts.

Our assessment involved examining the characteristics, abilities and functions of ALS methods. Through this analysis, our goal was to explore the impact of incorporating intelligence (AI) into learning systems on enhancing personalized learning for students. We investigated how AI driven ALS techniques can customize content delivery, adjust teaching approaches and offer tailored assessments to meet the preferences and requirements of learners. By identifying and evaluating these AI powered aspects, we aimed to highlight the advantages and efficiency of utilizing AI in learning systems.

Additionally, our study paper discusses the key challenges and limitations related to the incorporation of AI in ALS. We explore topics like data security because using AI requires handling and evaluating a lot of student data. We look at the ALS guiding principles and explore the moral issues that come up when artificial intelligence is used in adaptive learning systems. In order to ensure the responsible and equitable use of AI in educational contexts, ethical problems like privacy, bias, and fairness are closely examined.

Overall, our research paper presents an in-depth exploration of how ALS techniques, empowered by AI, can enhance personalized learning systems. The objective of this study is to present a comprehensive analysis of the relationship between AI and customized learning by elucidating the fundamental ideas of ALS, evaluating their benefits and drawbacks and also investigating their ethical implications. This study will also highlight how crucial educator's collaboration is to successfully integrating ALS into school environments.

2. Literature Review

2.1 Traditional Vs. Personalized Education

Traditional or conventional educational methods and personalized/individualized education represent two separate paradigms in the field of pedagogy. In the past traditional methods have served as the backbone of education for centuries, the emergence of personalized education seeks to address the limitations and shortcomings inherent in one-size-fits-all approaches. This comparative analysis explores the key differences between these two approaches. It also highlights the advantages of personalized education in meeting the diverse needs and preferences of learners in today's rapidly evolving educational landscape [11].

2.1.1 Approach to Instruction

Traditional education focusses on standardized curricula and its teaching strategies are central to conventional teaching. It supports students' progress through the curriculum at the same pace, regardless of individual learning readiness or proficiency [12]. The teacher is the primary source of information and instruction, and students play a relatively passive role.

While here in personalized education instruction is tailored to the individual learner's abilities, interests, and learning styles. Learners have the flexibility to progress at their own pace, allowing for deeper understanding and mastery. Moreover, technology and data-driven approaches enable the customization of content delivery and learning pathways [13].

2.1.2 Engagement and Motivation

In traditional education engagement may vary due to a lack of alignment between instructional methods and students' interests. Learners who struggle or excel may feel disengaged in a one-size-fits-all classroom [14]. While in personalized education, customized content and activities enhance learner engagement and motivation. Students have ownership of their learning, as they can explore topics that resonate with them [15].

2.1.3 Assessment and Feedback

In traditional learning assessments are often summative and occur after a set period, offering limited opportunities for real-time adjustment. Feedback may be delayed, hindering the learning process. While in the adaptive learning, there is a complete opposite. Continuous assessments provide ongoing insights into student performance and understanding [16]. Immediate feedback allows for prompt correction and improvement.

2.1.4 Flexibility and Adaptability

Traditional education have limited opportunities for collaborative and interactive learning experiences. Critical thinking and problem-solving skills may not be emphasized [17]. Whereas in adaptive learning collaborative projects and interactive learning experiences foster communication and teamwork. Emphasis on critical thinking and problem-solving skills enhances learners' ability to apply knowledge.

2.1.5 Collaboration and Critical Thinking

Traditional education have limited opportunities for collaborative and interactive learning experiences. Critical thinking and problem-solving skills may not be emphasized [18]. Whereas in adaptive learning collaborative projects and interactive learning experiences foster communication and teamwork. Emphasis on critical thinking and problem-solving skills enhances learners' ability to apply knowledge.

2.1.6 Teacher's Role

Teachers are primarily responsible for content delivery and classroom management in traditional learning. Tailoring instruction to individual students can be challenging in large classrooms. Teachers become facilitators and guides in personalized learning, providing personalized guidance and support. Technology assists educators in tracking student progress and adapting instruction [19].

2.2 Evolution of Personalized Education

The evolution of education has been marked by an ongoing endeavor to enhance the effectiveness of instructional methods and improve learning outcomes [20]. Famous conventional "one-size-fits-all" techniques of teaching have often failed historically in catering to the diverse learning needs and keeping up pace with that of students. It is evident that the emergence and evolution of Adaptive Learning Systems (ALS) represents a paradigm shift in education, capitalizing on technological advancements to deliver a personalized and dynamic learning experience [21]. This section traces the evolutionary trajectory of ALS and explores their pivotal role in shaping modern education.

With the advent of computer-assisted instruction (CAI) in the middle of the 20th century, the roots of the ALS can be traced all the way back to the introduction of technology in education. [22]. In the early days of CAI, there were basic types of personalized instruction available where students engaged with computer systems to get content that was customized to their unique reaction patterns. [23]. This was the first step towards realizing the potential of technology to recognizing the potential of technology to adapt instruction to individual learners' needs.

In order to gain the full advantage of data analytics and machine learning methods, ALS has gone one step further. The purpose of this analysis is to identify each student's strengths, weaknesses, and learning preferences by analyzing a variety of data, such as assessment results and interactions with learning resources. By doing so, we can say that it is now better equipped to spot patterns and trends in the way its students are learning in terms of how they learn. Through this data-driven approach, ALS is able to determine the best learning paths for each individual based upon the individual's requirements using a data-driven approach [24].

We can now process a wide range of data, including student performance, preferences, and learning patterns. The integration of artificial intelligence has greatly influenced the evolution of adaptive learning systems [25]. Today's AI-

based adaptive learning system is a groundbreaking technological advancement that has revolutionized the field of education. With its ability to independently implement sophisticated algorithms, this system has the power to dynamically adjust content delivery, sequencing, and assessment processes in real time. Gone are the days of static instruction platforms, as this application of AI has transformed adaptive learning systems (ALS) into highly adaptable and personalized learning environments.

One of the defining characteristics of ALS is its ability to dynamically adapt the content delivery process. Based on ongoing assessments and student interactions, ALS adjusts the level of difficulty, pace, and sequencing of instructional materials on a regular basis [26]. Students who can grasp concepts quickly are further presented with more advanced challenges, while those who require additional support will receive targeted instructions based on the level their needs. Due to this versatility, students are kept engaged and challenged to get best out of their abilities [27].

Over the short span of past few years, ALS has revolutionized the arena of instructional learning by providing learners with immediate and targeted feedback, which has made teachers continuously aware of learner's levels of understanding about the topic. Traditional education is often based on delayed assessments, which hinders learners' ability to make timely improvements in their learning [28]. On the other hand, ALS provide instant insight into performance which allow learners to address misconceptions and gaps in their knowledge as soon as possible. This real-time feedback loop enhances the learners understanding and facilitates the teacher for further personalization.

Furthermore, the real-time feedback increases understanding and simplifies mastery of the material. The best way to engage learners, is the use of gamification elements, interactive simulations, and collaborative tools which ultimately result in enhancing the learning experience and promoting the experiential learning [29]. Additionally, ALS has seamlessly integrated with Learning Management Systems (LMS) and other education technology platforms, creating a cohesive and interconnected educational experience.

3. Research Objectives and Methodology

To provide a comprehensive overview of the most recent insights into the application of artificial intelligence (AI) and adaptive learning systems (ALS) within the educational sector, an in-depth systematic literature review was meticulously carried out. For the purpose of this review, a structured and repeatable systematic search methodology was employed, ensuring a high degree of thoroughness and repeatability. The search was conducted over a period spanning from March 2023 to August 2023.

During this timeframe, an exhaustive full-text examination of relevant publications was completed. This process involved a careful selection based on specified inclusion and exclusion criteria that are typical of a systematic review. A systematic review, by its nature, is an intentional and highly structured process. It seeks to aggregate information systematically from a broad array of individual case studies. This methodical compilation of data and evidence is directed towards tackling predefined research questions. The approach is designed to minimize bias and to provide a clear and comprehensive synthesis of current evidence. Such insights are valuable to practitioners, policymakers, and scholars who aim to understand the current landscape of AI and ALS in educational contexts and to discern patterns, challenges, and opportunities within this rapidly evolving field [30].

We used the PRISMA-P (Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols) method of systematic review proposed by Moher et al. [31] for identifying and analyzing reliable literature in our systematic review. As part of the PRISMA-P method, systematic reviews are conducted in a structured manner to facilitate the development of systematic review protocols through the use of a 17-item checklist.

As part of our effort to cover as wide a variety of educational journals as possible, the following databases were searched: "Web of Science", an online library that provides access to leading academic publications, "IEEE Xplore", an extensive collection of scientific journals, "Science Direct", a significant repository of academic and professional articles and "Others", various other small platforms. To find the necessary articles, a combination of five groups of keywords was used: (1) adaptive learning systems, (2) AI in education, (3) enhancing education with AI, (4) AI powered adaptive learning systems, and (5) machine learning for personalized education.

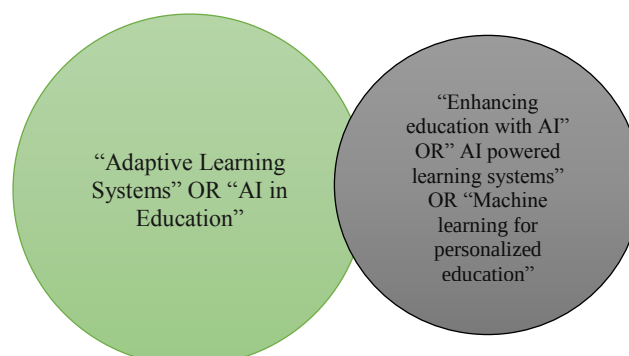


Fig. 1. Venn diagram of search articles

By entering the search strings into the apps of the aforementioned databases, we were able to find documents with the search terms in their titles, abstracts, and keywords. The following standards were used in compliance of PRISMA guidelines to choose which articles to be included in the final revision: (a) articles exclusively related to artificial intelligence and ALS in education; (b) Research articles that present empirical and primary findings; (c) articles published in English; and (d) articles published between 2020 and 2023.

Table 1. Inclusion and exclusion criteria

Criteria For Inclusion	Criteria For Exclusion
- Articles exclusively related to artificial intelligence and ALS - Articles presenting primary research - Articles published in English - Articles published between 2020 and 2023	- Articles not related to artificial intelligence and ALS - Articles not presenting primary research - Articles not published in English - Articles published before 2020

We conducted inductive and deductive analyses of the chosen publications, involving reading and rereading data to find analysis-relevant themes [32]. The technique involved two researchers who independently reviewed each paper, yielding an inter-rater reliability of 81% (Cohen's kappa coefficient). Differences were settled by conversation until consensus was attained. Frequency tables are used to display the themes.

During the initial search, a total of 526 articles were identified. To ensure relevance, the titles of these articles were carefully scrutinized, resulting in a narrowed pool of 299 potentially relevant articles. Further refinement was carried out by removing 49 papers that were deemed similar based on their abstracts, leaving a total of 255 papers for the next stage of screening. The next step involved subjecting these 255 papers to a thorough screening process, where inclusion and exclusion criteria were applied. The application of these criteria resulted in the identification of 105 papers that met the specified requirements and were eligible for further evaluation.

However, upon closer examination, it was discovered that 28 of these 105 papers were either loosely related or unrelated to the subject of the study. To ensure the integrity and validity of the research, a discussion was initiated among the researchers to address any disagreements regarding the inclusion or exclusion of these papers. Through a collaborative effort, a consensus was reached, and the unrelated papers were subsequently removed from consideration. After this rigorous screening process, a final set of 15 articles remained for in-depth analysis. These articles were selected based on their strong alignment with the research objectives, inclusion of relevant data, and overall quality. Now we had a focused and manageable set of articles to thoroughly analyze, extracting key insights and information to support their study as explained in Fig. 2.

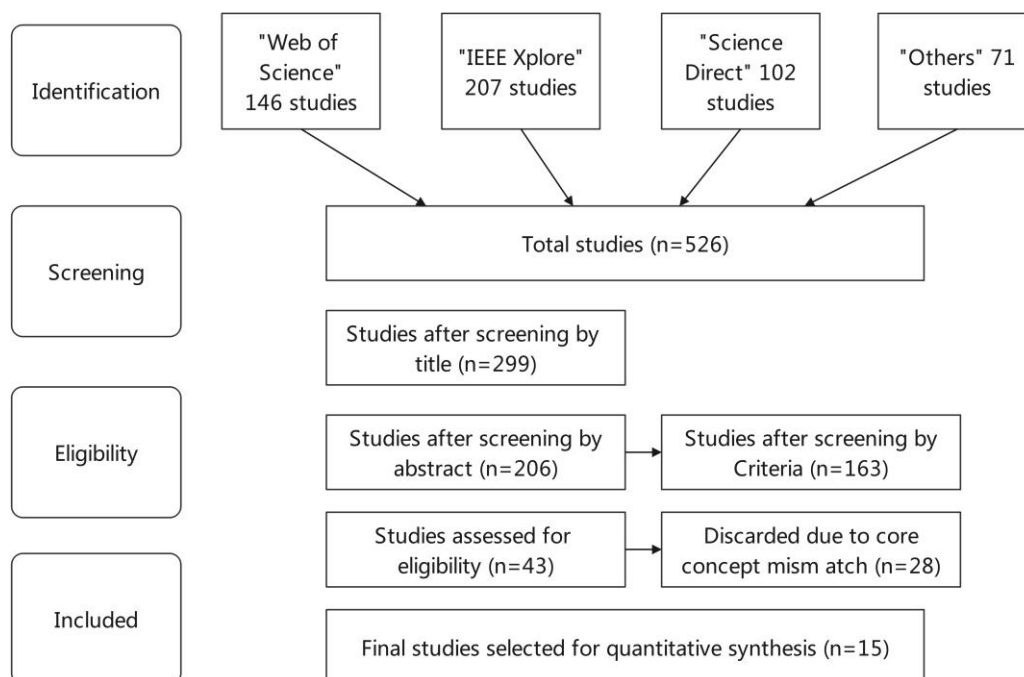


Fig. 2. PRISMA flow diagram of the systematic review process

4. Results

This comprehensive review incorporates an analysis of 15 research studies that are geographically distributed across 11 different countries, demonstrating a broad international interest in the field of AI in education. The breakdown of the studies per country is as follows: China is represented with five studies, illustrating a significant contribution to the research body, while the remaining countries are represented by a single study each, namely Canada, Czech Republic, Ghana, Germany, Greece, India, Malaysia, Norway, Turkey, and the United States.

The purpose behind this extensive literature review was to critically examine previous investigations and to evaluate the current status of artificial intelligence (AI) applications within the educational sector. By conducting this extensive review, insights into the advancements, challenges, and emerging trends in this dynamic field were sought.

Through the selected papers, the evaluation gave rise to three pertinent research questions, which are subsequently addressed in the analysis. Such questions would typically explore the effectiveness of AI educational tools, the perception of AI among educators and students, the technical challenges involved, the impact on educational outcomes, and possible future directions of AI in enhancing learning experiences.

The first research question is the following: How does the use of AI in adaptive learning systems contribute to personalized learning experiences for students? In answer to this query, the chosen articles were grouped in accordance with their educational focuses, and Table 2 provides a summary of the features of the included research.

Table 2. Summarized details of selected studies

Author(s) and Year	Country	Category	AI Tools	Ethics	Results
Newmann et al., (2021)[33].	Germany	2	Chatbots: Feedbot for self-study, Litbot: for mentoring students' reading	Not Followed	Promising results that bear the potential for digital mentoring to support students.
Yilmaz and Yilmaz (2020)[34]	Turkey	2	LMS log data	Not Followed	Provided self-assessment and personalized learning, improved academic performance, and instilled a positive attitude toward the course
Sapci and Sapci (2020)[35]	US	1	Data analytics, data visualization and real-time data analytics,	N/A	The paper proposes a framework for specialized AI training in medical and health informatics education.
Wang and Christensen (2020)[36]	China	2	Squirrel AI Learning	Partially Followed	The students who used Squirrel AI Learning independently outperformed those who were taught it traditionally.
Hayward et al., (2020)[37]	Canada	1	Moodle platform	N/A	Moderate student engagement.
Ashraf Alam (2022)[38]	India	2	Intelligent tutoring robots, Virtual Classrooms	Partially Followed	The use of artificial intelligence improves both the quality of instruction provided by teachers as well as student learning outcomes
Malinka et al. (2023)[39].	Czech Republic	2	ChatGPT	N/A	ChatGPT can be used to cheat, but also have potentially significant benefits to the educational system
Ahmad et al. (2021)[40]	Malaysia	1	AI	N/A	AI influences situational knowledge, teaching strategies, and both intrinsic and extrinsic motivation.
Gerogianni et al. (2020) [41]	Greece	2	Simulation modeling Utilized machine learning as an assistive artifact	Partially Followed	The application of machine learning can complement modeling and simulation in a number of ways to facilitate effective learning
Baidoo-Anu and Ansah (2023)[42]	Ghana	2	The generative AI tools like ChatGPT	Not Followed	Highlights some inherent limitations and provide recommendations to maximize teaching and learning
Ouyang and Jiao (2021) [43]	China	1	Artificial Intelligence paradigmatic approach	N/A	Present paradigm approach on how artificial can be used to address educational issues
Wang et al. (2020) [44]	China	1	Science vs others approach	Followed	AI techniques are more helpful for science learning than others
Z. He and X. Niu (2021) [45]	China	1	Human computer learning symbiosis	Followed	Insight on use of AI in sports education
Chen et al. (2021) [46]	China	2	Artificial intelligence based robots	Partially Followed	AI can have a game changing effect if used with caution
Kabudi, Pappas, and Olsen (2021) [47]	Norway	2	Machine learning algorithms and student models	Partially Followed	An analytical mapping of AI-enabled adaptive learning research, revealing key themes as well as gaps to guide further investigation

In order to categorize the selected articles and provide a comprehensive analysis, two distinct categories were established based on the emphasis of each publication. Articles that placed a greater emphasis on examining the effectiveness of adaptive learning systems were classified as Category 1. On the other hand, studies that focused more on exploring various AI techniques and algorithms to enhance personalized learning were categorized as Category 2.

Out of the 15 articles that were selected for analysis, 6 of them, accounting for 40% of the total, fell under Category 1. These articles delved into investigating the effectiveness of adaptive learning systems and likely explored factors such as learner outcomes, engagement, and overall instructional impact. The researchers of these studies aimed to assess the extent to which adaptive learning systems positively influenced the learning experience and educational outcomes.

Conversely, the remaining 9 articles, comprising 60% of the total, were categorized as Category 2 (Fig. 3). These publications were primarily concerned with exploring different AI techniques and algorithms that could be employed to enhance personalized learning. To be specific, these studies likely investigated various AI based approaches to create adaptive learning environments that catered to individual learners' needs and preferences.

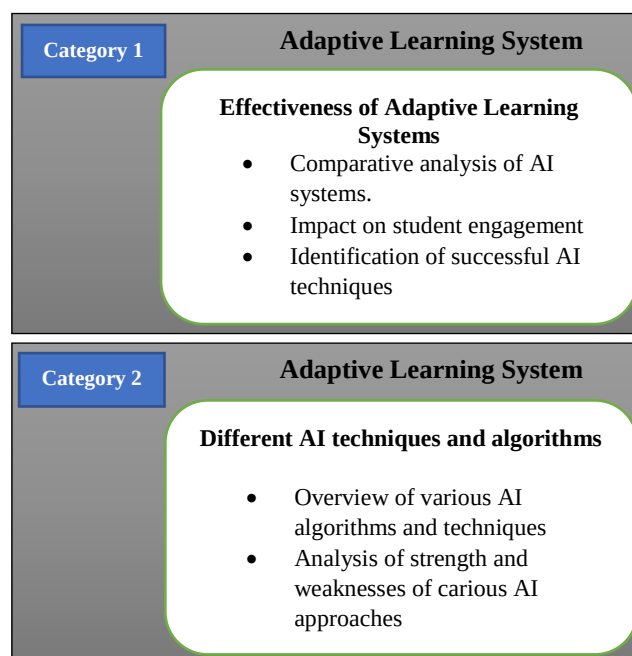


Fig. 3. Classification of selected articles

Most Category 1 studies investigated effectiveness of adaptive learning system in various contexts and situations. For example, Sapci and Sapci [35], the review highlighted the growth of AI education in medical and health informatics programs to build valuable skills for students, but also identified opportunities to improve teaching methods and resources to enhance learning. Another systematic review conducted by Hayward et al. (2020) [37], the paper provides a useful framework for understanding different AI approaches in education and their opportunities and challenges. The paper categorizes AI applications in education into three main paradigms: (i). Intelligent tutoring systems (ITS) (ii). Intelligent learning environments (ILE) (iii). Educational data mining (EDM). Collaboration between AI experts, educators, and learning scientists is needed to develop effective and ethically-sound applications.

Physical education is as crucial as the academic education because physical education provides diverse and significant benefits for students' physical, mental, social, and academic growth and development. It is an essential part of the educational experience. Our next authors Z. He and X. Niu (2021) [45] explains the impact of AI in physical education. The paper makes a case for integrating AI into PE programs in schools to create a new paradigm for physical education that is adaptive, engaging, and data-driven. AI should complement rather than replace PE teachers, enhancing human instruction rather than automating it entirely. Thoughtful design and ethical principles are necessary to use AI appropriately in education.

In our research, we identified many AI techniques and algorithms for specialized learning activities. In their 2021 article, Newmann et al (2021) [33], demonstrates the potential of AI chatbots to mentor and motivate students in higher education by providing personalized, conversational support for critical self-management skills. Students reacted positively and found the chatbot useful, trusting, and motivating. The conversational approach was preferred over just searching content. Chatbots can allow more personalized support for students at scale, complementing other learning resources. More research is needed on design strategies. Challenges include managing conversations on complex topics, maintaining engagement, and ensuring student privacy.

Omiros et al (2020), [41] presents an AI-enhanced framework to generate integrated, personalized learning pathways that adapt to each student's knowledge and interests. Initial results are promising. A prototype system called

TRAILS was developed and tested in a pilot study with 63 students over 5 months. Results indicated significant increases in competency development compared to a control group, demonstrating potential learning benefits. Challenges include accurately modeling complex competencies and student journeys, as well as scaling robust data infrastructure.

Keeping in mind the above mentioned papers we have found an answer to first question i.e. How does the use of AI in adaptive learning systems contribute to personalized learning experiences for students? AI personalization helps students feel recognized as individuals in the learning process, enabling them to have more focused and efficient learning experiences tailored to their specific backgrounds, objectives, strengths, and weaknesses. This has the potential to improve educational outcomes. Careful design considering ethics and student agency is crucial however.

Our second research question involved determining the challenges and limitations associated with the integration of AI in ALS. Chen et al (2021) [46] highlights the key challenges involve high development costs, need for specialized personnel, and limitations in fully recreating real patients. More research is still needed on optimal instructional uses, measurable outcomes, and how to combine robot simulation training with real experiences.

Wang et al (2020) [44] explains the challenges of artificial intelligence in adaptive learning systems. Challenges include limited teaching resources on AI, lack of teacher experience, and fitting new curriculum into packed schedules. Strategies include starting with short modular activities, leveraging online resources, providing teacher training, and focusing on real-world applications of AI skills. Assessment should evaluate skills application, not just knowledge, through students' AI projects and artifacts. With thoughtful implementation, AI literacy education can prepare students to participate responsibly in an AI-driven society.

Baidoo-Anu and Ansah (2023) [42] have some say on limitations and challenges. To maximize benefits, teachers should guide appropriate uses, set boundaries, detect AI-generated content, and focus on developing students' deeper skills. Generative AI is best used as a teaching aid, not a replacement. Curricula and activities should be re-designed around human-AI collaboration. Overall, generative models have excellent potential to enhance education but require careful oversight. Teachers, researchers, technologists, and policymakers must collaborate on ethical integration.

Following a systematic review of all these papers, we have compiled a list of the challenges and limitations associated with the integration of AI into ALS research. Adaptive Learning Systems (ALS) present a number of challenges and limitations in the integration of artificial intelligence (AI):

- **Data Quality and Availability:** To function effectively, artificial intelligence requires a large amount of high-quality data in large volumes. In adaptive learning, obtaining accurate and comprehensive data about each learner's interactions and progress can be challenging.
- **Lack of Interoperability:** Integrating AI with existing educational technology systems can be complex due to interoperability issues, especially if the systems use different data formats or standards.
- **User Acceptance and Resistance:** Students and educators might be hesitant to embrace AI-driven adaptive learning due to concerns about job displacement, changes in teaching dynamics, or discomfort with technology.
- **Data Privacy and Security:** AI-driven adaptive learning systems rely heavily on student data for personalization, which raises concerns about data privacy and security.
- **Bias and Fairness:** If the training data used for the AI models is biased, it can lead to biased recommendations and personalized learning experiences, potentially disadvantaging certain groups of students.
- **Content Adaptation Complexity:** Creating adaptive content that matches the learning needs of various students while maintaining educational quality requires careful planning and content expertise.
- **Limited Customization:** Some AI models might struggle to adapt to highly specialized or niche subjects, limiting their effectiveness in certain educational domains.
- **Complexity of AI Models:** Designing, developing, and fine-tuning AI models for adaptive learning requires advanced technical skills and resources that might not be readily available in all educational settings.
- **Scalability:** Ensuring that AI-driven adaptive learning solutions can scale to accommodate a large number of students while maintaining effectiveness can be a challenge.
- **Teacher Training:** Educators need training to effectively integrate AI tools into their teaching practices, and this training can be time-consuming and resource-intensive.

Our third question regarding the research was: What are the ethical considerations which arises during implementation of AI in adaptive learning systems? Wang and Christensen (2020) [36] highlights crucial ethical issues regarding implementation of AI based ALS. The study should be conducted ethically by respecting student privacy, agency, and welfare while responsibly leveraging data to advance learning. Ongoing oversight is needed. Ensuring students and parents were fully informed about the purpose of the study and use of the motivation data collected. Consent was likely obtained but not reported.

Hayward et al. (2020) [37] has explained various ethical issues regarding artificial intelligence based adaptive learning systems. According to authors, key priorities are respecting participant autonomy, minimizing risks/harms, and ensuring robust, unbiased methodology to generate actionable knowledge that improves inclusive educational practices. Participation must be completely voluntary. Since it involves a course, extra care is needed to avoid coercion. Grades/standing cannot be tied to participating.

5. Conclusion

This systematic review synthesized research on the integration of artificial intelligence (AI) into adaptive learning systems to enhance personalized learning experiences. The findings indicate that AI holds significant promise for advancing key capabilities of adaptive systems, including customized content recommendation, intelligent tutoring, data-driven learner modeling, and dynamic learning path adaptation. In particular, machine learning, neural networks, and natural language processing techniques, and data mining are being applied to enable more granular analysis of learner needs and performance as well as more dynamic and individualized instructional experiences. However, the review also highlights important limitations and challenges involved in effectively implementing AI in adaptive learning contexts. Ethical issues regarding learner privacy, accountability, and autonomy require careful consideration.

Overall, this review underscores the significant potential of AI to upgrade adaptive learning systems, but also gives reason for measured optimism. Purposeful integration of AI in education calls for collaborative efforts across disciplines paired with critical reflection on both capabilities and limitations. As adaptive technologies continue proliferating amidst increasingly vast amounts of learner data, developing ethical, effective, and accessible AI-enhanced personalized learning systems remains an important priority for improving education. Further interdisciplinary research on AI in education will help delineate responsible paths forward.

6. Limitation

To ensure that the systematic review process was as efficient as possible, a number of efforts were made in order to do so; however, there were still many limitations. Some peer-reviewed academic literature databases may not be able to contain all studies, or some studies may be published in languages other than English in the peer-reviewed academic literature databases. Although this is a systematic review of the field, artificial intelligence is a relatively new technical discipline, especially when it comes to education. Consequently, only a limited number of articles were included in this review as a result of this limitation. Additionally, further research is needed to establish optimal AI algorithm design, validate learning outcomes, outline best practices for human-AI interaction, and investigate long-term impacts of prolonged AI exposure on learner development. While AI provides tools to enhance learning personalization, human oversight and pedagogical principles must remain central to the design process.

7. Future Direction

It was generally found that there was no specific information provided in the selected publications about how different jobs require different skills and what curriculum needs to be followed. Educators need to adopt new learning methods in order to keep up with the emergence of intelligent systems in the classroom. It is very important that a student has a working understanding of how to assess biased data and evaluate innovative AI technologies through the use of AI applications and prediction modeling techniques. It is important for educators to become familiar with the implementation of appropriate machine learning algorithms and the development of innovative adaptive learning modules. It is also essential that they acquire the hands-on skills necessary to extract data, manage large datasets, and develop complex AI systems. To collaborate with data scientists, computer science students need to possess specialized skills. They should also become familiar with the programming languages Python, R, and SQL, as well as data analytics software.

References

- [1] Bostrom, N. and Yudkowsky, E., 2018. The ethics of artificial intelligence. In *Artificial intelligence safety and security* (pp. 57-69). Chapman and Hall/CRC.
- [2] Nilsson, N.J., 1998. Artificial intelligence: a new synthesis. Morgan Kaufmann.
- [3] Chen, L., Chen, P. and Lin, Z., 2020. Artificial intelligence in education: A review. *Ieee Access*, 8, pp.75264-75278.
- [4] Skinner, B.F., 1958. Teaching Machines: From the experimental study of learning come devices which arrange optimal conditions for self-instruction. *Science*, 128(3330), pp.969-977.
- [5] Hussain, M.I., Shamim, M., Ravi Sankar, A.V., Kumar, M., Samanta, K. and Sakhare, D.T., 2022. The Effect Of The Artificial Intelligence On Learning Quality & Practices In Higher Education. *Journal of Positive School Psychology*, pp.1002-1009.
- [6] El Miedany, Y. and El Miedany, Y., 2019. Flipped learning. *Rheumatology Teaching: The Art and Science of Medical Education*, pp.285-303.
- [7] Weber-Lewerenz, B., 2021. Corporate digital responsibility (CDR) in construction engineering—ethical guidelines for the application of digital transformation and artificial intelligence (AI) in user practice. *SN Applied Sciences*, 3, pp.1-25.
- [8] Kinshuk, Chen, N.S., Cheng, I.L. and Chew, S.W., 2016. Evolution is not enough: Revolutionizing current learning environments to smart learning environments. *International Journal of Artificial Intelligence in Education*, 26, pp.561-581.
- [9] Collins, A. and Halverson, R., 2018. Rethinking education in the age of technology: The digital revolution and schooling in America. Teachers College Press.
- [10] Yarbrough, J.R., 2018. Adapting Adult Learning Theory to Support Innovative, Advanced, Online Learning-WVMD Model. *Research in Higher Education Journal*, 35.

- [11] Abbas, N., Ali, I., Manzoor, R., Hussain, T. and Hussaini, M.H.A., 2023. Role of Artificial Intelligence Tools in Enhancing Students' Educational Performance at Higher Levels. *Journal of Artificial Intelligence, Machine Learning and Neural Network (JAIMLNN)* ISSN: 2799-1172, 3(05), pp.36-49.
- [12] Miseliunaite, B., Kliziene, I. and Cibulskas, G., 2022. Can holistic education solve the world's problems: A systematic literature review. *Sustainability*, 14(15), p.9737.
- [13] Alamri, H.A., Watson, S. and Watson, W., 2021. Learning technology models that support personalization within blended learning environments in higher education. *TechTrends*, 65, pp.62-78.
- [14] Fung, C.Y., Su, S.I., Perry, E.J. and Garcia, M.B., 2022. Development of a socioeconomic inclusive assessment framework for online learning in higher education. In *Socioeconomic inclusion during an era of online education* (pp. 23-46). IGI Global.
- [15] Hassan, J., Devi, A. and Ray, B., 2022. Virtual Laboratories in tertiary education: Case study analysis by learning theories. *Education Sciences*, 12(8), p.554.
- [16] Soslau, E., Gallo-Fox, J. and Scantlebury, K., 2019. The promises and realities of implementing a coteaching model of student teaching. *Journal of Teacher Education*, 70(3), pp.265-279.
- [17] El-Sabagh, H.A., 2021. Adaptive e-learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education*, 18(1), pp.1-24.
- [18] Asigigan, S.I. and Samur, Y., 2021. The Effect of Gamified STEM Practices on Students' Intrinsic Motivation, Critical Thinking Disposition Levels, and Perception of Problem-Solving Skills. *International Journal of Education in Mathematics, Science and Technology*, 9(2), pp.332-352.
- [19] Pendy, B., 2023. From Traditional to Tech-Infused: The Evolution of Education. *BULLET: Jurnal Multidisiplin Ilmu*, 2(3), pp.767-777.
- [20] Vadivel, B., Namaziandost, E. and Saeedian, A., 2021, November. Progress in English language teaching through continuous professional development—teachers' self-awareness, perception, and feedback. In *Frontiers in Education* (Vol. 6, p. 757285). Frontiers.
- [21] Gregg, A., Yu, J., Resig, J., Johnson, L., Park, E. and Stuczynski, P., 2021. Promising educational technology meets complex system: A 6-year case study of an adaptive learning project from initial exploration through the end of a pilot. *Journal of Formative Design in Learning*, 5, pp.62-77.
- [22] Dorfman, J., 2022. Theory and practice of technology-based music instruction. Oxford University Press.
- [23] McCalla, G., 2023. 2. The history of artificial intelligence in education—the first quarter century. *Handbook of Artificial Intelligence in Education*, p.10.
- [24] Gardner, J., O'Leary, M. and Yuan, L., 2021. Artificial intelligence in educational assessment: 'Breakthrough? Or buncombe and ballyhoo?'. *Journal of Computer Assisted Learning*, 37(5), pp.1207-1216.
- [25] Maghsudi, S., Lan, A., Xu, J. and van Der Schaar, M., 2021. Personalized education in the artificial intelligence era: what to expect next. *IEEE Signal Processing Magazine*, 38(3), pp.37-50.
- [26] Kabudi, T., 2023. Towards Designing AI-Enabled Adaptive Learning Systems.
- [27] Munshi, A., Biswas, G., Baker, R., Ocumpaugh, J., Hutt, S. and Paquette, L., 2023. Analysing adaptive scaffolds that help students develop self-regulated learning behaviours. *Journal of Computer Assisted Learning*, 39(2), pp.351-368.
- [28] Javed, A.R., Saadia, A., Mughal, H., Gadekallu, T.R., Rizwan, M., Maddikunta, P.K.R., Mahmud, M., Liyanage, M. and Hussain, A., 2023. Artificial Intelligence for Cognitive Health Assessment: State-of-the-Art, Open Challenges and Future Directions. *Cognitive Computation*, pp.1-46.
- [29] Mhlongo, S., Mbatha, K., Ramatsetse, B. and Dlamini, R., 2023. Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review. *Heliyon*.
- [30] Tinoca, L., Piedade, J., Santos, S., Pedro, A. and Gomes, S., 2022. Design-based research in the educational field: a systematic literature review. *Education Sciences*, 12(6), p.410.
- [31] MATHEWS-PETT, A.M.E.L.I.A., Gods and Robots: Myths, Machines, and Ancient Dreams of Technology. By Adrienne Mayor (Princeton and Oxford: Princeton University Press, 2018. Pp. xvi+ 275, acknowledgements, introduction, illustrations, photographs, glossary, notes, bibliography, index. \$29.95 hardbound.).
- [32] Pham, S.T., 2022. The distinctions of Heideggerian phenomenological research method. *Qualitative Research Journal*, 22(2), pp.261-273.
- [33] Neumann, A.T., Arndt, T., Köbis, L., Meissner, R., Martin, A., de Lange, P., Pengel, N., Klamma, R. and Wollersheim, H.W., 2021. Chatbots as a tool to scale mentoring processes: Individually supporting self-study in higher education. *Frontiers in artificial intelligence*, 4, p.668220.
- [34] Ustun, A.B., Zhang, K., Karaoglan-Yilmaz, F.G. and Yilmaz, R., 2022. Learning analytics based feedback and recommendations in flipped classrooms: an experimental study in higher education. *Journal of Research on Technology in Education*, pp.1-17.
- [35] Sapci, A.H. and Sapci, H.A., 2020. Artificial intelligence education and tools for medical and health informatics students: systematic review. *JMIR Medical Education*, 6(1), p.e19285.
- [36] Wang, S., Christensen, C., Xu, Y., Cui, W., Tong, R. and Shear, L., 2020. Measuring chinese middle school students' motivation using the reduced instructional materials motivation survey (RIMMS): a validation study in the adaptive learning setting. *Frontiers in psychology*, 11, p.1803.
- [37] Hayward, D.V., Mousavi, A., Carbonaro, M., Montgomery, A.P. and Dunn, W., 2022. Exploring preservice teachers engagement with live models of universal design for learning and blended learning course delivery. *Journal of Special Education Technology*, 37(1), pp.112-123.
- [38] Alam, A., 2022. Investigating sustainable education and positive psychology interventions in schools towards achievement of sustainable happiness and wellbeing for 21st century pedagogy and curriculum. *ECS Transactions*, 107(1), p.19481.
- [39] Malinka, K., Peres ni, M., Firc, A., Hujnak, O. and Janus, F., 2023, June. On the educational impact of ChatGPT: Is Artificial Intelligence ready to obtain a university degree?. In *Proceedings of the 2023 Conference on Innovation and Technology in Computer Science Education V. 1* (pp. 47-53).

- [40] Pu, S., Ahmad, N.A., Khambari, M.N.M., Yap, N.K. and Ahrari, S., 2021. Improvement of Pre-Service Teachers' Practical Knowledge and Motivation about Artificial Intelligence through a Service-learning-based Module in Guizhou, China: A Quasi-Experimental Study. *Asian Journal of University Education*, 17(3), pp.203-219.
- [41] Gerogiannis, V., Tsoni, E., Born, C. and Omiros, I., 2020, January. Prioritizing Software Features based on Stakeholders Satisfaction/Dissatisfaction and their Hesitation. In *4th International Conference on Algorithms, Computing and Systems (ICACS 2020)*.
- [42] Baidoo-Anu, D. and Owusu Ansah, L., 2023. Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. *Available at SSRN 4337484*.
- [43] Ouyang, F. and Jiao, P., 2021. Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence*, 2, p.100020.
- [44] Wang, H., Liu, Y., Han, Z. and Wu, J., 2020, June. Extension of media literacy from the perspective of artificial intelligence and implementation strategies of artificial intelligence courses in junior high schools. In *2020 International Conference on Artificial Intelligence and Education (ICAIE)* (pp. 63-66). IEEE.
- [45] He, Z. and Niu, X., 2021, November. Applying Artificial Intelligence to Primary and Secondary School Physical Education. In *2021 2nd International Conference on Information Science and Education (ICISE-IE)* (pp. 1577-1581). IEEE.
- [46] Chen, J., Zhan, X., Wang, Y. and Huang, X., 2021, June. Medical Robots based on Artificial Intelligence in the Medical Education. In *2021 2nd International Conference on Artificial Intelligence and Education (ICAIE)* (pp. 1-4). IEEE.
- [47] Kabudi, T., Pappas, I. and Olsen, D.H., 2021. AI-enabled adaptive learning systems: A systematic mapping of the literature. *Computers and Education: Artificial Intelligence*, 2, p.100017.

Authors' Profiles



Muhammad Jawad Mustfa, a dedicated Computer Science educator with a comprehensive background spanning over seven years, contributes to this systematic review. Holding both a Bachelor's degree in Computer Science and a Bachelor of Education, Mustfa has continually enriched his pedagogical expertise and technical acumen. His commitment to advancing educational methodologies is evident through his active participation in various trainings and certifications specifically tailored for educators. Through this work, Mustfa aims to shed light on how Artificial Intelligence (AI) can be effectively implemented in adaptive learning systems to revolutionize the educational landscape by providing personalized and engaging learning experiences for students.



Sidra Ashiq, an accomplished educator, brings a wealth of experience to the forefront of this paper. With a career dedicated to shaping minds and fostering an environment of growth and innovation, she have not only broadened her pedagogical skill set but also deepened her understanding of how technological advancements. This paper benefits from Ashiq's keen insights and her commitment to exploring the integration of Artificial Intelligence (AI) into learning systems.

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