

Comprehensive Overview of the Concept and Applications of AI-based Adaptive Learning

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Abstract: This paper provides a comprehensive understanding of the concept and the applications of AI-based adaptive learning, underlining its potential to revolutionize education in terms of personalization and optimization. Such systems offer personalized learning experiences by analysing vast pools of data so that the strengths and weaknesses of each student can be pinpointed. Personalization increases the learning outcomes and engagement of students by providing appropriate challenges and timely feedback. The SWOT analysis underpins a critical evaluation that AI-enhanced adaptive learning brings about: the strengths, weaknesses, opportunities, and threats in its adoption. Among the advantages are higher efficiencies, accessibility, data-driven decision making, and automated assessment. However, significant weaknesses have been well documented as a lack of personal contact, privacy issues, high costs, and possible technical problems. Furthermore, a Force Field Analysis is conducted, involving 112 test subjects, to investigate and analyse the driving and resisting forces of implementing AI adaptive

learning. Driving forces include advancing technology, educational needs, social and economic pressures, facilitative government policies, and the ability to identify learning patterns, resisting forces emanating from technological failures, costs, privacy and security threats, lack of interpersonal interaction, and issues about ethics and sociology. The paper illustrates the dynamic interplay of these factors to provide strategies that would harness the supporting forces and mitigate the barriers in front. It concludes that AI-enabled adaptive learning faces several significant obstacles. At the same time, it is strongly potential for transformation into an inclusive and effective system.

Keywords: Artificial Intelligence; education; adaptive learning; SWOT; Force Field Analysis

1 Introduction

Education and technology are closely linked, with the former being shaped by education systems and methods for centuries. However, the enhanced fast technological developments over the last decades opened new dimensions for education. The rapid increase of artificial intelligence is a significant factor of advancements in educational technologies, supporting the spread and further development of adaptive learning systems. Adaptive learning assists the personalization and optimization of learning processes by adjusting learning to the individual needs, abilities, and learning styles of students. [1], [2]

Algorithms analyse a great deal of data in efforts to determine individual student's strengths and weaknesses, therefore, giving relevant feedback and providing timely interventions to foster their learning. [3] Such a personalized approach shall not only enhance the result of learning [4]-[7], but will also strengthen students' engagement and motivation since the material will present an appropriate level of challenge. Other challenges to the implementation of AI-enhanced adaptive learning technologies are related to privacy concerns, ethical dilemmas, and adequate training for teachers. Nevertheless, the fusion of adaptive learning with AI has a promising future in transforming education into a more inclusive and practical setting. [8]-[10]

Adaptive learning systems can tailor instruction to the individual needs of students due to the integration of machine learning technologies and advanced data processing techniques. The tracing and assessment of performance and learners' behaviour are processed in real-time with tools offering constant corrective feedback and creating individual learning pathways. With AI-based adaptive learning systems, the abilities and weaknesses of individual learners can be recognised, allowing the provision of targeted content and exercise recommendations to maximize the efficiency of learning. [11], [12]

AutoTutor is a tutoring system designed to engage students in interactions through natural language for pedagogical purposes in areas about complex topics such as Newtonian physics, computer literacy and critical thinking. It emulates human tutoring by engaging students in conversations and monitoring their cognitive states besides providing individually tuned feedback aimed at raising learning outcomes. Affective AutoTutor targets to improve learning results by detecting and responding to students' emotional states—boredom, confusion, frustration—in addition to their cognitive states. It includes facial recognition, body language, and conversational cues to accommodate dynamic adjustments of instructional strategies. The authors provide evidence from more than 20 controlled experiments showing that these systems quadruple the possibility of radically improving learning, often about a full grade. It reviews how big data analytics could massively improve e-learning services by personalizing and optimizing learning experiences. In this paper, various methodologies and tools associated with the collection, processing and analysis of large datasets from generated e-learning platforms are discussed. Such insights allow a better understanding of students' behaviour and, in prediction of learning outcomes, another way to provide proposed feedback and recommendations that would raise efficiency and effectiveness in learning. The paper also addresses the challenges, and the ethical concerns related to data privacy and security as big data in education is affected. [13]

AI in education is helpful not only in case of individual learners but it also has far broader social and economic-benefiting capacities. It is through technological advances that an education system is appropriate for responding to various educational challenges more efficiently, as well as to changing needs, including those emerging because of digital education. [1]-[3]

The paper gives and contextualizes the state of the art regarding the concept and practical use of AI-based adaptive learning. It presents the technological background, the applied methods, the problems and perspectives of the researchers and education practitioners that may occur within this domain. The paper also elaborates on the paradigms of restructured education as a result of the application of AI-based adaptive learning and it demonstrates the further influence on the future of education systems and practices. The article would hence not be an academic treatise; it would be a guide for educational professionals who would like to follow, and ultimately seize, such opportunities presented through AI in education.

2 Background

In order to demonstrate the importance of artificial intelligence and education, one of the world's largest databases of publications, Scopus, was used and the following Boolean string was applied:

(TITLE-ABS-KEY (artificial AND intelligence OR ai) AND TITLE-ABS-KEY (education OR learning)) AND PUBYEAR > 1999 AND PUBYEAR < 2025

Figure 1 shows the publications over the last nearly 25 years.

Documents by year

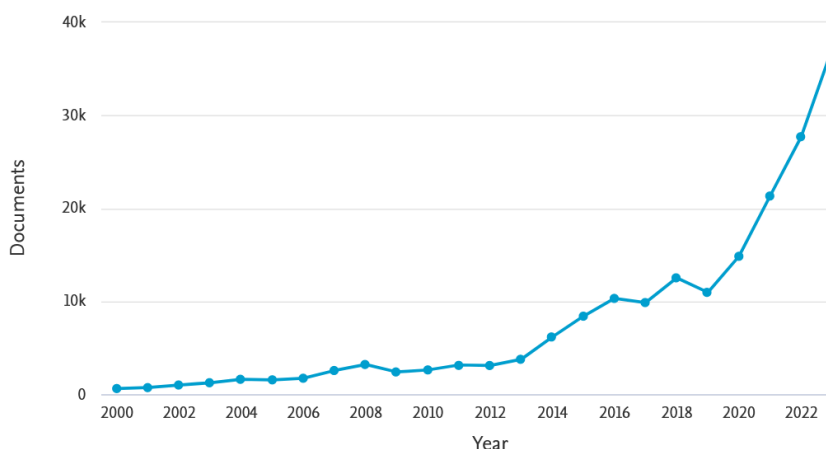


Fig. 1.

Number of publications in AI and education over the last nearly 25 years

A notable growth in the publications within AI-enhanced education has been realized in the last 25 years.

Early in the late 1990s and early 2000s, the publications in this area were relatively few. This is because AI and machine learning technologies were still very young; thus, their application in education was very theoretical. The research of those days was limited to basic technical implementations and potential application area studies.

Meanwhile, as of the mid-2010s, AI technology was already at a much more advanced stage. Improvements in data storage and processing abilities, along with advancements in improving machine learning algorithm efficiencies, have enabled AI to increasingly become a constituent of useful practical educational tools. During this period, the number of publications on the subject increased steadily because of the growing number of researchers and educators who began to recognize the potential of AI applications.

In recent years, particularly since early 2020, interest in AI-enhanced education has been sharply increasing among scientists. The digitalization of education and the development of online learning systems, which were also accelerated by the global pandemic, gave new impetus to developing and researching AI-based education systems. Adaptive learning platforms, intelligent tutoring systems, and automatic assessment systems are all prime contributors to a strikingly high increase in interest and publications within the field.

All in all, the research on AI in education has grown exponentially in the last 25 years. The progress from the early experimentation stage to the present-day stage, where systems have been deployed reflects the ever-increasing interest in technological innovations and the betterment of educational methodologies.

2.1 What AI Means in Education

The term "AI in education" is used to mean AI technologies for diverse application needs in teaching and learning. The role of AI in education spans several areas, starting from the delivery of personalized learning experiences. As a result, AI technology allows personalization in the different provisions of education with the aid of such features as abilities, interests, and learning rhythms. Besides, AI can also be helpful in automated assessment and feedback systems that enable the teacher to deploy more advanced and frequent learning experiences. The systems can take off the administrative pressure from educators as well, as they can get an assessment of student performance done speedily and correctly, freeing much time to spare for the student by offering more support or mentoring. AI-based tutoring systems can also help students to understand more challenging parts of the material. The systems can offer learners various aids interactively, such as explanations and further tasks to help them go through. AI helps in data-driven decision making by analysing the data from learners and trends in making better decisions on behalf of educational institutions and education professionals. Therefore, they can notice problems or challenges that the learner might be going through beforehand and offer well-tailored support promptly. It is also used to develop adaptive learning tools and platforms that dynamically respond to the needs and development of learners. For example, this includes automatic adaptation or customization of educational content and real-time monitoring of learner performance. At last, AI can support the automated production of learning resources and foster the development of various skills, for example, in language learning or mathematics. These will assist educational institutions in the better management of the educational process, skills development and student performance. All these applications and opportunities reveal how AI can be crucial in improving educational systems and supporting learners in the digital age. [12]-[16]

2.2 A Brief Overview of How AI has Evolved in the Education Sector

There have been considerable developments in AI in the education sector within the last decade. Early uses of AI technologies were mainly targeted at automating some educational processes, all of which aimed at reducing the administration workload. The first steps included introducing automated assessment systems that could quickly score student performance and objectively provide feedback. Subsequent development of AI has enabled personalization of the learning experience and education content. Further development of adaptive learning platforms and teaching tools increased educational efficiency and effectiveness since they were able to change dynamically with the development and performance of the learner. Other applications are student performance analytics, which support education professionals in decision making. Data-driven teaching strategies and interventions at the educational institution level might give an added advantage to tracking and anticipating differences in student achievement, providing support in more tailored ways. Technological advances bring further challenges and opportunities for AI in the education sector. In the future, AI is expected to bring further innovations in education, for example through the development of interactive virtual learning environments that further improve student engagement and learning outcomes. [17]-[21]

2.3 The Latest Trends and Developments in the Use of AI in Education

The use of AI in education has created new trends in the education factor, which are still developing and spreading continuously. These trends affect the whole process of education and the development of the learner, too. One prominent area supporting personalized learning being implemented by AI is through Adaptive Learning Systems. These systems are capable of making education dynamic tailored to the needs and learning styles of individual learners; moreover, they allow optimum learning experiences. Another broad area of the application of these systems is automated assessment with feedback. AI technologies can quickly evaluate learners' performance in a highly objective way. This would free teachers from additional time spent mentoring individuals and providing individualized learning support, thus the efficiency of the learning process can be improved by decreasing administrative burden. Some other domains where AI can be useful in educational institutions are predictive analytics and decision support. For instance, AI can be applied in analysing and interpreting student data to achieve student performance prediction, hence assisting the educator in identifying problems and responding at the right time with proper solutions. Using AI is inherent in interactive and immersive experiences through AR and VR applications that make learning more engaging and enjoyable and, so better understanding can be

fostered. Finally, the question of ethical and privacy issues arising from the use of AI in educational applications must be considered. With this stipulated technology, developers and experts in education are keen on developing transparent and compliant AI systems regarding principles of privacy and fairness. Developments and trends outlined here show how AI could underpin quality enhancements in education and efficiency in educational processes to support learners' personalized development and learning pathways, which is necessary for the technological development of the future and the expectations of the industry. [3], [22]-[25]

2.4 Current Applications of AI in Education

The application of artificial intelligence in education has grown massively over the past years. For instance, an intelligent educational software lets learners immediately join and experience personalized learning. They usually automate all kinds of academic processes, from the optimization of learning material delivery to adaptive reactions that take into account the learning progress and requirements of learners. This not only increases learner motivation and engagement, but also boosts learning results. Adaptive learning systems are one step ahead toward meeting the requirements of personalized learning. They adapt dynamically to each learner's learning style and progress and offer personalized learning pathways wherein the content is tailored accordingly. In this way, every student can progress at a rate unique to them and by their needs; thus, efficiency and the effectiveness of learning are enhanced. Virtual teachers and learning assistants are also playing important roles in learning. These AI-based entities interact with the material to understand and answer questions in detail. This becomes quite critical in the online learning environment where human face-to-face interactions and mentoring may be less possible. It automates assessment and feedback systems, enabling rapidity and objectivity in measuring student performance. It also allows teachers more time to engage in individual support and tracking. Moreover, predictive analytics in education provides educational institutions with a better way to understand and act on behavioural patterns of students and their differences in performance, and accordingly, helping in continuous improvement and development in education is achievable. All these various AI applications and technologies improve quality and efficiency toward personalization and support learners' development in the digital age. Further innovations and additional development in the future of this relationship between AI and education will set an even more efficient process on its way to realization for better results of the learner. This type of research and development has already shown many positive results in the teaching-learning process. [26]-[34]

3 Materials and Methods

In addition to traditional education, artificial intelligence can play a significant role in adaptive learning. In order to explore the strengths, weaknesses, opportunities and threats of AI supported adaptive learning, a SWOT analysis was applied, and a Force Field Analysis with test subjects was conducted to identify the factors that can facilitate smooth adoption and those that may cause resistance.

3.1 Applying SWOT Analysis to Adaptive Learning Supported by Artificial Intelligence

A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is a strategic planning tool used to identify and assess the strengths, weaknesses, opportunities and threats of an organisation, project or system. The purpose of a SWOT analysis is to help decision-makers to gain a comprehensive picture of the situation in the area under consideration and to develop effective strategies on this basis.

Steps of SWOT Analysis:

- 1) Strengths: Identifies the internal positive factors of the project or a system that provides a competitive advantage.
- 2) Weaknesses: Identifies internal negative factors that may hinder success.
- 3) Opportunities: Identifies positive external factors that may create a favourable environment for growth or development.
- 4) Threats: Identifies external negative factors that may threaten the success of the project or system.

The SWOT analysis will help decision-makers to get a comprehensive picture of the benefits and challenges of AI-enhanced adaptive learning. This analysis enables them to develop strategic actions to exploit strengths, minimise weaknesses, exploit opportunities and address threats.

The extensive literature research of the analysis was carried and after that the factors related to each group were formulated.

3.2 Force Field Analysis in the Case of Adaptive Learning Supported by Artificial Intelligence

Force Field Analysis is a powerful tool to understand and evaluate the forces and barriers in the AI-enabled adaptive learning environment and to identify and highlight the resources and factors that support the implementation and successful operation of AI-based adaptive learning. At the same time, the analysis will also help to identify and understand the factors that may hinder the successful

implementation of AI-based adaptive learning and develop strategies and actions to leverage resources and address barriers. Overall, the analysis will help educational institutions and developers to understand the various risks and take appropriate precautionary measures.

3.2.1 Test Subjects

For the Force Field Analysis, 112 people were asked (50 (44.65%) women and 62 (55.35%) men) over the age of 18 ($M_{age}=28.69\pm12.69$) to rate the importance of each factor on a scale of 1 to 10. The test subjects were either still university students or people with a university degree.

3.2.2 Applied Factors

Following a literature search the following factors were identified for the Force Field Analysis:

- 1) Forces FOR adaptive learning supported by AI: technological development, educational needs, social and economic pressure, supporting regulations and identifying learning patterns.
- 2) Forces AGAINST adaptive learning supported by AI: technical challenges, costs, privacy and security, lack of personal contact and ethical and social issues.

4 Results and Discussion

This chapter presents the results and discussion of the SWOT analysis and the Force Field Analysis.

4.1 The SWOT Analysis of AI-enhanced Adaptive Learning

The integration of artificial intelligence (AI), which is rapidly evolving in education today, presents both exciting opportunities and challenges. A SWOT analysis is used to review the strengths, weaknesses, opportunities and threats associated with the application of AI in adaptive learning.

	Helpful	Harmful
Internal	STRENGTHS • Efficiency: AI will help to make the learning process more efficient by saving time and resources. • Accessibility: AI can make learning possible where traditional education is hardly available. • Data-driven decision making: AI can provide analytics-based feedback that, in effect, leads the teachers and institutions toward a more informed phase of making better decisions. • Personalised learning: Artificial intelligence provides the potential to deliver experiences that are adaptive to individual students' needs and ways of learning. • Automated assessment: AI will grade students' performance fast and with total accuracy, saving teachers time and getting immediate feedback.	WEAKNESSES • Lack of personal contact: AI cannot replace the emotional support of human teachers and the personal contact between students and teachers. • Privacy: AI systems collecting and processing data can create problems regarding privacy and security. • Costs: The development and maintenance of AI technologies can be expensive. • Technical problems: In the event of malfunction or failure of AI systems, teaching processes may be disrupted.
External	OPPORTUNITIES • Innovation: AI makes it possible to work out new methods and tools of teaching and therefore denotes innovation in education. • Lifelong learning: Quite possibly, AI could facilitate lifelong learning and continuing professional development. • Global accessibility: Artificial intelligence will achieve a nebulous educational gap across the earth through quality education accessible everywhere. • Collaboration and networking: AI platforms increase collaboration possibilities and networking between students and teachers.	THREATS • Job losses: Penetration of AI into education could trigger job losses, hence social problems. • Technology dependency: The education systems can rely too heavily on technology, which may cause problems in case of disruptions technically. • Cultural and social differences: Artificial intelligence systems should be designed considering all the cultural and social differences. If not, biased results and inequalities may well appear. • Ethical issues: A variety of issues will be created by the ethical use of AI in education related to transparency in decision making and minimizing bias.

Fig. 2.
The SWOT analysis of AI-enhanced adaptive learning

As for the strengths pertaining internally to AI concerning enhancing practices in education, one of the excellent tools would be adaptive learning. It creates a personalized learning experience that fits individual learner needs and styles. That makes learning not only more effective but also enjoyable to go through the process of learning. Effectiveness is another critical strength; AI automatizes the educational process, saving time and resources—for instance, in assessment and feedback. Moreover, it provides access to education through geographical outreach—such as letting education in peripheral or under-resourced areas where ease of access to training is a problem. Another significant benefit is data-driven decision-making, wherein AI provides several valuable insights through its analytics in helping educators at both the pedagogically informed strategy and improvement levels.

These strengths are, however, accompanied by intrinsic weaknesses that will have to be taken seriously into consideration. Despite its effectiveness for individualized learning, AI can never replace the role of teachers' personal presence and emotional support in students' lives. Another serious issue is data protection; because AI systems collect and process a considerable amount of personal data, strict safeguards will have to be put in place to protect students' data. Moreover, the implementation and maintenance of AI technology are instead an expensive affair for an educational institution. Also, should technical failures or malfunctions related to the AI systems occur, there may be disruptions in education procedures—hence portraying the risks in an AI-dependent system.

Concerning externalities, AI presents several opportunities around innovation and impact globally in education. It enables the invention of new teaching techniques and tools, thus continuing the current innovation in the education sector. Another significant merit of AI is that it forms continuous development for professionals and supports lifelong learning; this helps professionals develop their ever-changing skills throughout their careers. Furthermore, AI can potentially reduce global inequality in education by providing access to quality education from anywhere globally. Moreover, it facilitates collaboration and networking between students and educators across the globe using AI platforms for a better collaborative learning environment.

At the same time, all these opportunities are associated with several threats that should be considered in trying to make the most out of AI for education. For example, job redundancy may result in social problems, while education powered by AI could increase dependency on technologies; in the case of some technical glitches, this could lead to severe problems. Another dimension to consider in the design of AI systems that avoids undistorted outcomes and furthers discriminatory inequalities is related to cultural and social differences. Critical ethical concerns linked to the use of AI in education, like algorithmic transparency of decision making or minimization of bias, are also relevant.

4.2 Force Field Analysis in the Case of Adaptive Learning Supported by Artificial Intelligence

Force Field Analysis is a powerful strategic planning tool that allows identifying and analysing the forces that support and hinder change. In the case of AI-supported adaptive learning, in Table I. the descriptive statistics of the subjects' responses for both types of forces is presented.

TABLE I
DESCRIPTIVE STATISTICS OF THE RESPONSES OF TEST SUBJECTS ($N=112$) FOR EACH FACTOR

Forces FOR adaptive learning supported by AI					Forces AGAINST adaptive learning supported by AI				
Factors	Min	Max	Mean	SD	Factors	Min	Max	Mean	SD
Technological Development	6	10	9.19	1.05	Technological Challenges	2	10	7	2.47
Educational Needs	10	10	10	0	Costs	6	10	8.04	1.45
Social and Economic Pressure	5	10	8.28	1.52	Privacy and Security	7	10	9.06	0.94
Supporting Regulations	3	10	6.22	2.2	Lack of personal contact	4	10	7	2.13
Identify Learning Patterns	6	10	8.22	1.39	Ethical and Social Issues	4	10	7	1.71

Technological progress has forces of adaptive learning: $M = 9.19$, minimum and maximum values are 6 and 10, respectively, with a standard deviation of 1.05, thereby indicating strong support toward the adoption of adaptive learning. For all responses to education needs, they scored 10, indicating unanimous support for this factor.

Socio-economic pressure also represents a remarkable supporting factor, with a mean of 8.28, a minimum of 5, a maximum of 10, and a standard deviation of 1.52. In the context of regulation support, the responses range more than the others, from a minimum of 3 to a maximum of 10, with a mean of 6.22 and a standard deviation of 2.2. The medium support for these measures was shown. The other vital factor that supports them is identification in learning patterns, with a mean of 8.22, the minimum being six, the maximum 10, and a standard deviation of 1.39. Among those forces that impede adaptive learning, technological challenges have an average value of 7, a minimum value of 2, and a maximum value of 10, with a variance of 2.47 that could indeed present a significant barrier. Significant barriers are also the costs, with an average value of

8.04, minimum of 6, maximum of 10, and standard deviation of 1.45. The highest barriers are, more precisely, privacy and security issues, where the average is 9.06, minimum 7, and maximum 10 with a standard deviation of 0.94; hence, the concern is very high. The barriers included ethical-social problems and a lack of personal contact. In summation, the Force Field Analysis would identify that while AI-enabled adaptive learning has many strong enabling forces, it also carries significant barriers against technology-related challenges, cost, privacy, and security.

Figure 3 shows the main forces in favour of AI-enabled adaptive learning and the distribution of responses per test subject. The forces can be grouped into five categories: technological development (F1), educational needs (F2), social and economic pressures (F3), supportive regulations (F4), and identification of learning patterns (F5).

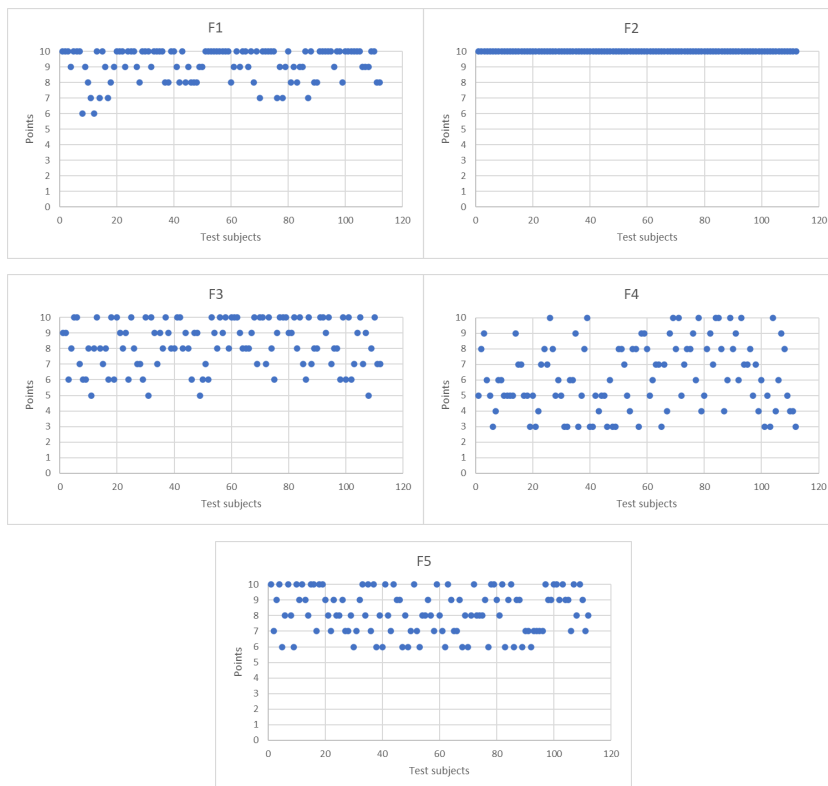


Fig. 3.

Forces FOR adaptive learning supported by AI. F1: Technological development F2: Education needs
 F3: Social and Economic Pressure F4: Supporting Regulations F5: Identify Learning Patterns

Overall, Figure 3 clearly shows that AI-enabled adaptive learning is strongly supported by technological and educational needs, as well as social and economic

pressures. Supportive regulations and identification of learning patterns also provide significant, albeit somewhat more moderate, support.

Figure 4 shows the main opposing forces to AI-enabled adaptive learning and how the responses are distributed across the test subjects. Technological challenges, cost, privacy and security, lack of personal contact, and ethical and social issues are the five categories into which these forces have been grouped.



Fig. 4.

Forces AGAINST adaptive learning supported by AI. F1: Technological challenge F2: Education needs F3: Privacy and Security F4: Lack of personal contact F5: Identify Learning Patterns

Overall, Figure 4 clearly shows that the implementation of AI-enabled adaptive learning faces several significant obstacles. Technological challenges, cost, privacy and security issues are particularly significant barriers. Lack of personal contact and ethical and social issues are also important barriers that need to be addressed for successful implementation.

Figure 5 shows Force Field Analysis in the case of adaptive learning supported by Artificial Intelligence based on the previous information.

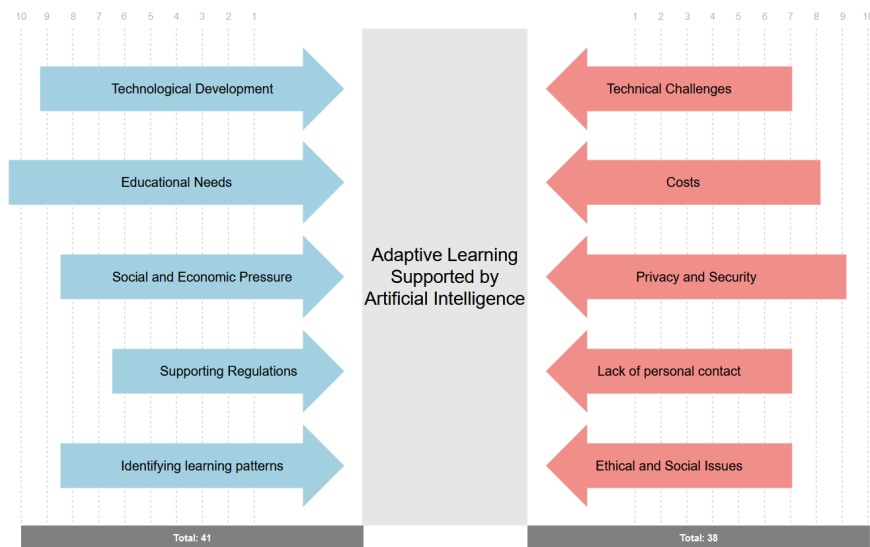


Fig. 5.

Force Field Analysis in the case of adaptive learning supported by Artificial Intelligence. The total score of the supporting forces was 41, while the total score of the opposing forces was 38, so overall the supporting forces were stronger.

Technological progress is among these driving supporting forces. Incessant advancement in innovative technologies becomes the big driver for the effectiveness and uptake of adaptive learning systems. Meeting educational needs is also crucial, and these systems will be able to provide reasonable support through adapting to the changing needs. Furthermore, social and economic pressures play a massive role in increasing acceptance and implementation of the systems, owing to that current social and economic realities are adopting progressive and efficient educational alternatives. The weak level of supportive regulations also assists in advancing adaptive learning.

In conclusion, identifying learning patterns is ultimately what measures the effectiveness of an adaptive learning system through the ability of AI technologies to result in personal learning experiences. Conversely, some of the significant barriers include technological challenges. These challenges and the fast pace of technological development can hinder the adoption and sustainability of adaptive learning systems. Cost is also a solid deterring factor because these systems require substantial financial investment for their development and maintenance. Privacy and security concerns are particularly critical barriers since data security, and protection of personal data are of paramount concern in educational systems. The following minor barrier is the lack of personal contact; this potentially limits human interactions and hence might reduce a good learning experience and effectiveness. Another significant barrier is the ethical and societal issues related

to introducing adaptive learning systems, raising a series of moral and societal dilemmas that must be overcome to apply adaptive learning to society.

In a general way, it is evident from Figure 5 that AI-enabled adaptive learning needs to overcome many significant barriers regarding implementation and operation; however, it presents an array of vital supporting factors related to successful implementation.

5 Limitation of the Study

Consequently, given that the present study is a comprehensive analysis of AI-based adaptive learning, several limitations should be acknowledged. First, regarding the Force Field Analysis, the sample size is relatively small, totalling 112 participants, which has implications for the generalisability of findings. The second limitation is that this review had more of a technological and pedagogical focus with regard to the issues of adaptive learning, while wider social-cultural or institutional issues that could influence its implementation were not examined thoroughly. Thirdly, as a consequence of the continuous development of AI, some of the findings presented here are likely to be outdated over time due to newer results. Last but not least, the discussion in this section includes ethical issues related to data privacy and possible biases in AI algorithms, but further investigation through empirical research is needed for full comprehension of its impact on the system of education.

Conclusions

With the help of AI, the main objective is to design adaptive learning that will change the education system and ensures personalized as well as optimized learning experiences. Technological development, educational needs, and social as well as economic pressures are very strong drivers for the adoption of these systems. The technological developments are further strengthened by regulatory support and the identification of learning patterns that enhance the effectiveness of adaptive learning systems.

However, it still faces several challenges. These barriers could include but are not limited to technology, high associated costs, privacy and security issues, ethical issues, and social concerns. Therefore, professionals in education and policymakers must face these barriers to form ways to overcome them to tap the potential of AI-based adaptive learning.

Resultantly, from the SWOT and Force Field Analysis, it is clear that there will be much to gain with AI adaptive learning; however, the risks and challenges must be managed and a comprehensive approach from educational institutions and developers to consider the enabling and disabling factors is required. In this line,

AI-based adaptive learning is, therefore, the single way of improving the learning process, learner engagement, achievements, along with an inclusive and effective learning environment.

In conclusion, the promising future of AI-based adaptive learning will see the light of success when its proper implementation is ensured with all technological, ethical and societal challenges undertaken and education systems developed continuously.

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