

Artificial intelligence in education - State of the art

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Article history

Received May 24, 2022
Revised June 6, 2022
Accepted June 7, 2022
Published June 9, 2022

ABSTRACT

Information and communication technologies (ICT), e-learning, mobile learning hypermedia have considerably improved education, but today artificial intelligence offers us a variety of possibilities that we were previously unaware of and leading us to a new revolution known as Education 4.0. This article presents a literature review of journal and research articles in artificial intelligence in the field of education (AIED) published between 2019 and 2021 on the scientific database ScienceDirect. Through a bibliometric selection based on selective criteria, we were able to highlight the most requested AIED technologies and their applications. We also talked about real-world examples of how AIED tools can be used in many educational contexts and disciplines. This research can serve as a starting point for future research to be aware of trends in AIED applications and future directions.

Keywords: Artificial intelligence, Education, AIED, AI in Education, AI

I. INTRODUCTION

Today, artificial intelligence (AI), which according to Whitby is defined as the engineering of computers and computer technologies based on the intelligent behavior of humans, animals and machines [1], is becoming an integral part of our daily life at a fast and accelerated pace. This branch of computer engineering is implemented in various fields namely: finance, health, security, geolocation, education etc.

Our present study is interested in the application of artificial intelligence in education (AIED). Education has always been a subject of innovations in many forms, with the aim of improving the process of teaching and learning, among these innovations, we find technological innovation, in particular artificial intelligence. Artificial Intelligence provides a panoply of computer technologies such as natural language processing, artificial neural networks, machine learning, deep learning and more [2], enabling the personalization of the learning, providing dynamic assessments, facilitating meaningful interactions in learning experiences, etc. [3].

This position paper offers a discussion to summarize the main applications of AIED, trends and future directions in scientific research as well as a description of relevant technologies, methods and techniques used in this field. To achieve this goal, two main questions were chosen:

- First, what are the applications of artificial intelligence in education and their educational benefits?
- Second, what are the applications of artificial intelligence in the field of education that represent a trend in scientific research?

A comprehensive review based on a bibliometric approach is used to select empirical studies regarding this research scope. The main objective was to select studies from scientific databases and journals specialized in AIED then to analyze them in order to deduce the current status and trends of research in this field, in other words to highlight the current state and future directions of AIED technologies and applications.

Regarding the plan of our paper, it will be the following: in the next section, we will present a state of the art of AI in education, then in the third section, we will discuss the method and the research process implemented during this study. The fourth section will be a deduction from the most requested AIED technologies and applications in scientific research. After that, a conclusion and future perspectives will be the subject of the last section.

II. BACKGROUND

A. Artificial Intelligence

In 1950, Alan Turing developed for the first time the idea of the "thinking machine", which represents a programmable computer device capable of passing the Alan Turing test called "Imitation Game" [4] [5]. The imitation game is a conversation between an interlocutor, a person, and a machine in separate rooms, in which the interlocutor must figure out who the person and machine is. This design gave the spark to the research and development of artificial intelligence (AI) as a discipline in various fields [4] [5].

In 1955, John McCarthy coined the term (AI) that designates a computer capable of reasoning, communicating and learning, in other words, a machine able to imitate the cognitive functions of the human being [6]. According to several authors [7] [8] [9] AI is defined as a field that studies computers which perform cognitive functions, such as learning and problem solving, that are generally associated with the human mind. Popenici and Kerr add that AI is a set of computational systems that can learn, adapt, synthesize, self-correct, and use data for complicated processing tasks in the same way as humans can [10]. We can then deduce that the AI is the results of several years of research and development made by experts in various fields, namely: mathematics, linguistics, cognitive sciences, psychology, education [11] etc. These decades of continuous work have given birth of a set of computer technologies that are inspired by the functioning of the nervous system and the human body, introverted under the banner of this science as defined by stone et al. [12].

In fact, there are many AI techniques, used in many fields, including AIED, across various applications. In the following, we will present relatively recent and widely used AI techniques and terminologies.

First, we cite the algorithms, which are one of the pillars of AI; because when we talk about AI, we are actually talking about the development of sophisticated and efficient algorithms [13]. Second, Machine learning (ML), which is a subset of AI, refers to the process that enables a machine to learn autonomously from a large amount of data and make predictions [14] [15] [16] [17]. To do this, ML uses several algorithms belonging to the field of computer science and statistics such as clustering, classification, decision tree learning, reinforcement learning (RL), inductive logic programming and networks Bayesians [2]. Third, deep learning (DL) which is a subset of ML. However, in addition to ML functionality, DL allows extracting higher-level features from data by adopting multiple layers [18]. LeCun, Bengio, and Hinton, adds that there are three types of deep learning algorithms: supervised, semi-supervised and unsupervised [19]. Fig 3 depicts the relationship between DL, ML, and AI, which demonstrates that one is a subset of the other.

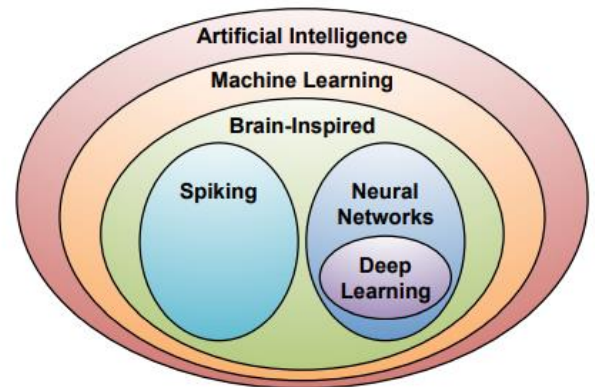


Figure 1. Relationship Between Deep learning, Machine learning and Artificial intelligence [20] [21] [22].

The greatest way to convey artificial intelligence's potential is to look at how it is currently used in various sectors. Here are a few examples:

- Finance: Today, AI is widely used in finance to automate complex tasks, increase profits, include benefits for customers and businesses, improve privacy and data protection, ensure financial stability, rate credit, detect fraud etc. Among the applications of AI in the field of finance, we cite:
 - Improving insurance services by using Robotic Process Automation for example to process complaints [23].
 - Study multiple markets at the same time automatically and analyze large amounts of information about price levels and market changes using algorithmic trading, in order to achieve faster trading at the best possible prices as well as reduce exchange rate errors related to psychological causes and emotions [24].
- Marketing: Predicting future trends, locating target users, recommending beneficial content, ad optimizations, sales forecasting are all AI applications in marketing through various techniques like machine learning, text mining, data mining, virtual reality, digital voice interaction, neural network etc. [25].
- Healthcare: The medical industry has been regularly affected by artificial intelligence, as it represents the most promising field of application for this technology. For years, research has demonstrated the great potential for using AI in medicine, this technology that has made it possible to increase and improve clinical practices such as decision-making capacity, the selection of appropriate treatments, diagnosis diseases, prevention of disease risk through interpretation of clinical reasoning and patient genomes etc. Among the technologies used are:

- Machine learning (i.e. detecting the presence or absence of diabetic retinopathy using fundus photographs [26]).
- Deep learning (i.e. using computed tomography images to diagnose pulmonary nodules [27])
- Artificial neural networks (i.e. in order to achieve dermatological level precision in the diagnosis of skin cancer, researchers used convolutional neural networks trained on 129,450 clinical pictures [28]) and more [29].
- Education: With the emergence of communication technologies, education is changing on a daily basis. Nowadays, the teaching-learning process calls more and more on new technologies, in particular artificial intelligence and its various subsets and techniques. Here are some of the most interesting applications without going into the details, because in what follows we will address the various aspects of artificial intelligence in education (AIED) [30].
 - Personalization of content using machine learning algorithms [9].
 - Automatic translation using natural language processing (NLP) techniques [11].
 - Online supervision of student activities on platforms such as Grammarly, TurnItIn and White Smoke [31] [32] [33].
 - Detection of at-risk learners using learning analytics [34].
- In 2017: Synthesis appropriation, learning adaptation, self-correction and data use for complicated processing tasks using AI-based computer systems [39].
- In 2020: Assist students in identifying knowledge gaps and receiving personalized guidance, minimizing the day-to-day workload of instructors and allowing them to better follow their students as well as providing important insights to administrators and decision makers at the institutional level [40].

One of the main challenges of AIED is to improve education by creating better applications, systems or learning environments that can provide customized learning guidance or adapted learning for each individual according to his/her profile and interests [41] [42]. To achieve this, various techniques are implemented (e.g. natural language processing, artificial neural networks, machine learning, deep learning etc.) [43] [44], which will be discussed in detail in the following section. The latter will be dedicated to the definition and features of the most requested AIED technologies and applications.

III. RESEARCH METHODS AND PROCESS

To answer the research questions that examines the literature on AI in education, we performed a study based on the bibliometric approach [45] in the form of a phased selection to collect relevant studies eligible for descriptive statistical analyzes (see figure 2 for more details).

To implement this approach, we decided to conduct an electronic search of the global scientific, technical, and medical research database, ScienceDirect [46], given the impossibility of investigating the vast amount of online publications and open access resources. We decided to choose ScienceDirect for the following reasons: (1) it provides the latest research and literature articles indexed and peer reviewed. (2) It offers search solutions allowing advanced bibliometric analysis through queries with Boolean operators and nested clauses. (3) It provides clever and intuitive capabilities to help users stay informed and perform more effectively and efficiently in their fields. (4) It allows a continuous workflow that fluidly transitions from book to book, topic to topic, and discipline-to-discipline, allowing researchers to make better and faster decisions. (5) It includes a wide range of disciplines, such as physical sciences and engineering, social sciences and humanities, life sciences. (6) It recommends other articles based on reading history and Scopus citation data. This ensures that time is used efficiently and effectively [47].

The search terms and keywords used were in the form of combinations, such as ("Artificial Intelligence" AND "Education"), ("AIED" AND "Technologies"), ("AIED" AND "Applications") OR ("AI" AND "Educational"). This series of searches on ScienceDirect resulted in a total of 10859 articles. In addition, strict selection criteria were applied to achieve the research objectives, namely:

Only open access review and research articles published between 2019 and 2022 were chosen, the article must be written in English, the research must be AI-based in an

B. Artificial Intelligence In Education (AIED)

Artificial intelligence in education (AIED) is a field of scientific research that has emerged over three decades and is particularly interested in the development of AI-based tools to support and understand the teaching-learning process [13] [35].

Year after year, the demand for the techniques of the IA for educational purposes has increased, taking into account the enormous possibilities and potentials it offers, such as:

- In 1987: Automatically resolving learner issues in a humanistic way as well as providing appropriate feedback, using intelligent tutoring systems based on AI techniques [36].
- In 2003: Using students' past performance to automatically estimate exercise progress and remediation during a training session through intelligent tutoring systems [37].
- In 2009: The use of artificially intelligent tutors to assess student analyzes and provide real-time responses [38].

educational context and must have studied applications and technologies in AIED, we have excluded presentations from our sample. This selection process allowed the retention of 32 articles, which represent a sufficient amount to carry out this study. Table 1 presents the work examined in this study.

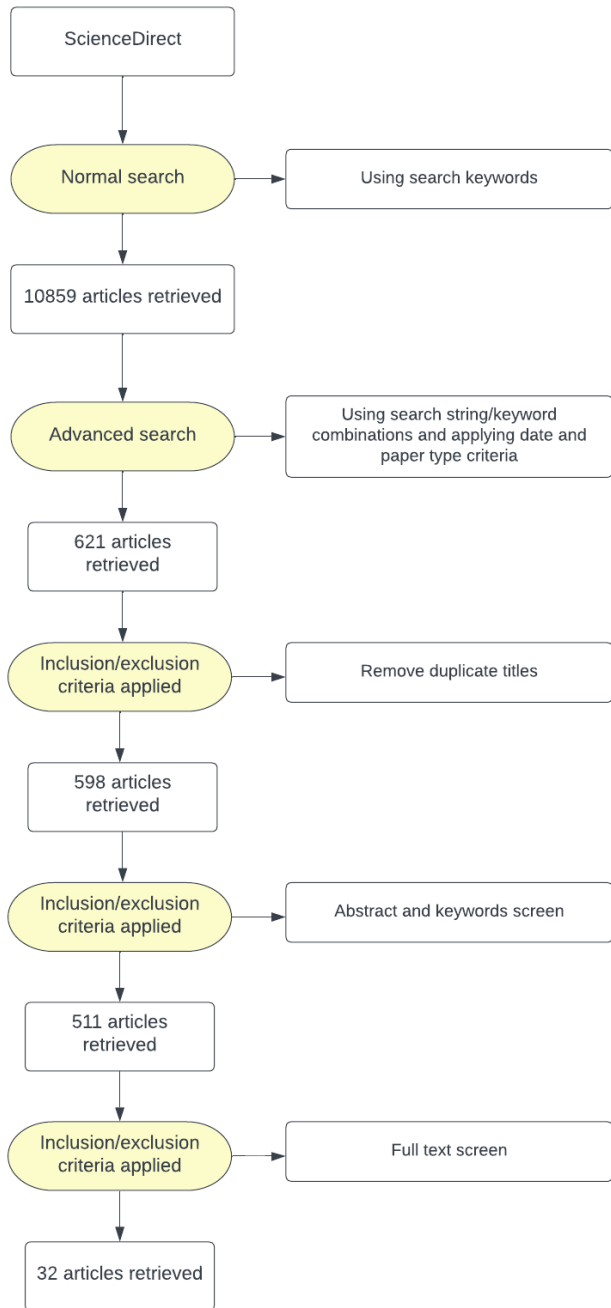


Figure 2. Flow Chart Of The Methodology Followed

TABLE I. WORK REVIEWED

Ref	Year	Title
[48]	2019	English Education Game using Non-Player Character Based on Natural Language Processing.
[49]	2019	Implementation of academia 4.0 for engineering college education.
[71]	2019	Concept of expert system for creation of personalized, digital skills learning pathway.
[85]	2019	Identification of personal traits in adaptive learning environment: Systematic literature review.
[86]	2019	Integrating machine learning into item response theory for addressing the cold start problem in adaptive learning systems.
[50]	2020	Lifelong Learning in higher education using Learning Analytics.
[40]	2020	Artificial intelligence innovation in education: A twenty-year data-driven historical analysis.
[42]	2020	Vision, challenges, roles and research issues of Artificial Intelligence in Education.
[2]	2020	Application and theory gaps during the rise of Artificial Intelligence in Education.
[43]	2020	A multi-perspective study on Artificial Intelligence in Education: grants, conferences, journals, software tools, institutions, and researchers.
[72]	2020	Learning recommendation with formal concept analysis for intelligent tutoring system.
[73]	2020	Integration of an intelligent tutoring system in a magnetic resonance simulator for education: Technical feasibility and user experience.
[82]	2020	Adaptive learning path recommender approach using auxiliary learning objects.
[87]	2021	Learning analytics dashboards for adaptive support in face-to-face collaborative argumentation.
[51]	2021	Human-centered artificial intelligence in education: Seeing the invisible through the visible.
[70]	2021	AI-enabled adaptive learning systems: A systematic mapping of the literature.
[52]	2021	Chatbots applications in education: A systematic review.
[53]	2021	The Role of Machine Learning and Artificial Intelligence for making a Digital Classroom and its sustainable Impact on Education during Covid-19.
[54]	2021	Application of Artificial Intelligence powered digital writing assistant in higher education: randomized controlled trial.
[44]	2021	Artificial intelligence in education: The three paradigms.
[3]	2021	AI technologies for education: Recent research & future directions.
[74]	2021	An intelligent tutoring system for supporting active learning: A case study on predictive parsing learning.
[75]	2021	How are students' emotions related to the accuracy of cognitive and metacognitive processes during learning with an intelligent tutoring system?
[60]	2021	Artificial neural network analysis of the academic performance of students in virtual learning environments.
[76]	2021	Conversational agents in MOOCs: reflections on first outcomes of the colMOOC project.
[83]	2021	Adaptive online learning for IoT botnet detection.
[84]	2021	Deep auto encoders to adaptive E-learning recommender system.
[77]	2022	Providing recommendations for communities of learners in MOOCs ecosystems
[78]	2022	Extended reality (XR) virtual practical and educational eGaming to provide effective immersive environments for learning and teaching in forensic science.
[79]	2022	Motivation Effect of Animated Pedagogical Agent's Personality and Feedback Strategy Types on Learning in Virtual Training Environment.

[80]	2022	How pedagogical agents communicate with students: A two-phase systematic review.
[81]	2022	An AI-based open recommender system for personalized labor market driven education.

IV. AIED TECHNOLOGIES & APPLICATIONS

In AIED, three ultimate objectives are key to dramatically improving educational practice: Provide personalized learning, Offer dynamic assessments and Facilitate interactions. Our study has revealed a wide variety of AIED technology applications that can be used to achieve these objectives. These applications are divided into three paradigms, the learner as recipient, the learner as collaborator, and the learner as leader.

The first paradigm is the least learner-centered as AIED technology applications are used here to represent knowledge models and direct cognitive learning through knowledge acquisition reinforcement. In the second paradigm, these applications are put into practice to support learning through collaboration with the learner. This collaboration aims to benefit from emerging student information to provide more effective learning, through an adaptive learner model. The third model, which reflects the ultimate goals outlined at the beginning of this section, relies on AI as a tool to augment human intelligence, while providing real-time information about learning, empowering learners to learn, and making education a complex adaptive system that includes several entities (the learner, the instructor, the information and the technology) [44].

Among the revolutionary applications of AIED studied in our research are those presented in the following graph.

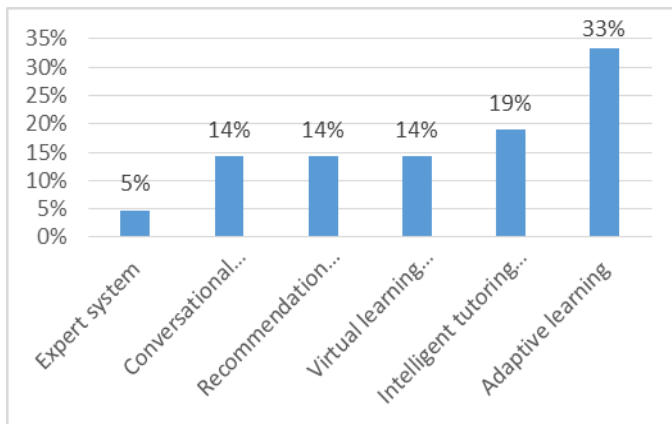


Figure 3. AIED Applications Extracted From Our Sample

According to figure 3, adaptive learning, with a proportion of 33%, is the most common type of artificial intelligence application in the research addressed in this study, followed by intelligent tutors with 19%, Conversational agents, Recommendation systems, Virtual learning environments with 14%, and expert systems with 5%. These applications all aim to improve learning, but each one is distinguished by additional educational benefits, as seen in the table below.

TABLE II. EDUCATIONAL BENEFITS OF AIED APPLICATIONS

AIED applications	Educational benefits
Expert system	<ul style="list-style-type: none"> Identify personalized digital skills learning pathway
Conversational agents	<ul style="list-style-type: none"> Improve students' engagement Improve learning interactions Improve learning outcomes Improve intrinsic motivation Improve Learning outcomes
Recommendation system	<ul style="list-style-type: none"> Improve learning Provide adaptive learning based on learning style Reduce the knowledge gap Optimize the learning process
Virtual learning environments	<ul style="list-style-type: none"> Facilitate access to teaching resources Inhance performance of students Make it easier to monitor the activity Facilitate effective online teaching Reinforce learning Improve intrinsic motivation Improve Learning outcomes
Intelligent tutoring system	<ul style="list-style-type: none"> Provide adaptive learning based on learning style Improve user experience Encourage students to learn through experimentation
Adaptive learning system	<ul style="list-style-type: none"> Provide adaptive content Adapt the Learning Presentation Personalize Learning pathway Improve learning performances Enhance help seeking behavior Provide counseling Increase students' knowledge Enhance students' engagement Maximize student score Enhance learning attitude

Regarding the artificial intelligence technologies and algorithms adopted to implement these applications, we cite the following:

TABLE III. AIED TECHNOLOGIES

AIED applications	AIED Technologies
Expert system	<ul style="list-style-type: none"> AI-Based rules
Conversational agents	<ul style="list-style-type: none"> learning analytics
Recommendation system	<ul style="list-style-type: none"> Rule-based reasoning Machine learning Topic modeling Labeling techniques
Virtual learning environments	<ul style="list-style-type: none"> Artificial neural network Data mining algorithms
Intelligent tutoring system	<ul style="list-style-type: none"> Rule-based reasoning Fuzzy rules
Adaptive learning system	<ul style="list-style-type: none"> Data mining algorithms Regression techniques Machine learning Naive Bayes Decision Tree K-Nearest Neighbors Support Vector Machine

In order to expand on our findings, we will go through this application in further depth in the next sections, as well as the software tools that were used to implement these technologies.

A. Adaptive Learning Systems

AI technologies have offered researchers and educational technology companies the opportunity to develop adaptive or personalized learning systems or environments (PLS/E), which can orchestrate learner interaction and provide personalized individual learning to enhance learning experiences⁷. Between the research that has examined the effects of PLS/E, we will highlight a few cited in the review conducted by Ke Zhang and Ayse Begum [3].

- According to a study of undergraduates in computer programming courses using the PLS system the learning outcomes and experiences were improved [55].
- Cheung et al. confirmed that personalized learning materials and resources were beneficial in the teaching / learning process through an experience of over 1300 participants in Hong Kong [56].

Several platforms that allow for content customization and personalization using machine-learning algorithms, including [30]:

- Knewton
- Cerego
- Immersive reader
- CALL

B. Conversational Intelligent Agents

Conversational intelligent agents are AI-based learning applications that assist learners during the learning process using natural language dialogs. These technologies can interact with learners individually, learn from experience and comprehend the learner's behavior in order to provide personalized assistance [57].

One of the uses of educational agents is Pounce, the agent used by Georgia State University, which assists students in walking through text to complete incomplete tasks on specific deadlines [58]. In 2017, researchers conducted a study to see how conversational agents affected students' enthusiasm in foreign language classes. After a week with the agent, students' attention waned, according to this research of 122 students [59]. We also point out that few studies have looked into the consequences of conversational agents, implying that additional empirical study is needed [3].

C. Virtual Learning Environments (VLEs)

First, virtual learning environments make it possible to study from anywhere in the world, which helps attract more students. Second, VLEs allow students to interact more easily with their teachers as well as facilitate access and acquisition of educational resources [60]. Third and according to Griol,

Molina, and Callejas, this type of environment has been able to boost learners' learning and engagement by utilizing the simulated experience provided by virtual reality and AI techniques [61]. Its setting has also proven to be beneficial to autistic children and adults as a social communication environment [62]. Finally, we can note that 'Google Apps for Education' is one of the many virtual learning environments that are growing increasingly popular [63].

D. Intelligent Tutoring System (ITS)

Tutors or intelligent agents are systems that attempt to provide learners with immediate and tailored feedback as well as relevant counsel, usually in an automatic manner [64]. According to the studies presented by Ke Zhang and Ayse Begum in their review, ITS increases learning, prepares students to learn new subject, and improves their performance [3].

Chassignol et al. give examples of several intelligent tutoring system platforms and applications [9], namely:

- ACTIVE Math
- MATHia
- Why2Atlas
- Viper
- DeepTutor
- Carnegie Learning
- AutoTutor

E. Recommendation Systems

As the name suggests, these tools help users find the content they are interested in through preference-based filtering. In education, these systems make it possible to recommend learning resources by explicit and implicit methods. The implicit methods are generally based on the actions of the user (example, spending time watching a video, clicking on a link, research etc.), for what is explicit, we speak of the evaluations made by the user concerning a domain or teaching material. Recommendation systems are widely used in various fields, namely [65]:

- Entertainment (Netflix, YouTube).
- E-commerce (Amazon).
- Education (X5Learn) [66].

F. Expert Systems

Expert systems are computer software that use AI to provide guidance and assistance to students in solving problems that would require human expertise. An expert system seeks to reproduce the knowledge of an expert in a specific field (science, mathematics, education, etc.) and integrate it with data traceability to provide assistance in pedagogical planning, to improve the potential of Learning Management Systems (LMS) and to enhance the quality of

interactions [3] [67] . The studies covered by Ke Zhang and Ayse Begum have shown that Expert Systems can model how users interact with LMS. In another context, their use has reduced the anxiety associated to mathematics learning [3].

G. Others

In addition to these AIED applications, there are still educational scenarios that use AI techniques, as mentioned in [68]. First, scoring and assessing papers and exams using techniques like image recognition, supervised machine learning for text classification and predicting student final grades. Here is some examples of software tools used to apply AI technologies for scoring [69]:

- IntelliMetric
- Intelligent Essay AssessorT
- E-rater
- Criterion
- MY Access!
- Bayesian Essay Test Scoring System (BETSY)

Second, the performance prediction based on stewardship (Attendance), Grades, GPA (grade point average) or Marks. The techniques used in this scenario are Recursive Clustering technique (eg grouping students according to prerequisites, co-requisites and work), Based neural network, Supervised Machine learning, machine learning regression methods. Some learning environments designed for this purpose are [70]:

- The LeaPTM system
- The Early Recognition System

Third, the use of machine learning-based assessments to test student knowledge and generate constructive feedback about student learning which will help achieve learning goals. Here are some platforms [70]:

- LearnSmart
- Personal Assistant for Life-Long
- Learning (PAL3)
- DeepTutor
- Protus
- Smart Sparrow
- Tamaxtil
- Affective tutoring
- System (ATS)
- QuestionIT

To conclude this section, we mention that as long as AI is in development as long as the techniques, application and platform of AIED appear and develop to include other spheres and meet other needs. The following table presents one of the

software tools used to apply AIED technologies in some discipline.

TABLE IV. SOFTWARE TOOLS USED TO APPLY AIED TECHNOLOGIES [43] [70] [7].

Discipline	Name of app
Programming Language	<ul style="list-style-type: none"> • SQL-Tutor • The intelligent Teaching Assistant for programming (ITAP) • ALEA • QuizGuide and Flip • FIT Java Tutor • Gerdes' tuto
Math	<ul style="list-style-type: none"> • Carnegie Learning • CueThink • DreamBox Learning • Talk2Learn • TrueShelf • Thinkster Math • Symbolab • Quizlet • Talk2Learn • Maths AI App
Language	<ul style="list-style-type: none"> • Cognii • Edwin • Elemental Path • GlobalEnglish • Grammarly • iTutorGroup • KidSense • Lingco Classroom • Linguix • MyGrammarCheck • Newsela • Yabla • Noplag App • Nuance • Pimsleur • QuillBot • Quizlet • Ready4 • Rosetta Stone Language Learning • VIPKID • Word Bricks • CASTLE • I-ETER • Web Passive Voice Tutor • WUFUN (for Chinese university students learning English) • Your Verbal Zone (for Turkish students learning English vocabulary) • E-Tutor (for learning German as a second language) • TAGARELA (for learning Portuguese at the university level) • Robo-Sensei (for Japanese) • Spanish for Business Professionals (SBP) • Duolingo • Busuu • Speexx • Babbel • Memrise • Magiclingua
literacy	<ul style="list-style-type: none"> • Amira

V. DISCUSSION

This part will examine the findings while also responding to the study questions presented in the introduction, namely:

- What are the applications of artificial intelligence in education and their educational benefits?
- What are the applications of artificial intelligence in the field of education that represent a trend in scientific research?

Before starting this discussion and as mentioned by Coppin in [8], artificial intelligence is machine's capability to adapt to new settings, solve issues, plan devices, and execute a variety of other tasks that need a level of intelligence similar to that found in humans. This means that AI can take the form of different applications in various fields, such as in the field of education, which is the subject of this study.

Based on the results of our research, we can see that there are several applications of AI in education, each with its own set of goals and problems to solve. Among these applications, there are six major systems, namely: expert system, conversational agents, recommendation system, virtual-learning environments, intelligent tutoring system, and Adaptive learning system. Each of these systems aims to improve the teaching-learning process in its own way, whether by providing students with intelligent human-like support, by reproducing the knowledge of an expert in a specific field to help the learner answer a problem, or by assisting students in finding educational content, that interests them through preference-based filtering. All these and other purposes are the educational benefits of AIED applications.

In terms of the most common system in our data sample, which can be considered as a research trend in the field of AIED, we cite adaptive learning systems, which represent 33% of all systems (Figure 3). This sort of system strives to improve student learning performance, knowledge, and engagement while providing learning content tailored to each learner's emotional and cognitive needs.

To conclude this section, we would like to point out that future study should include other databases in order to increase the number of papers examined, as well as keywords like machine learning and deep learning.

In our next research, we aim to deepen the field of adaptive learning by conducting a large systematic study of the literature in various reputable databases and journals.

VI. CONCLUSION

The objective of our study was to answer two questions mentioned in the introduction. The first aims to determine the applications of artificial intelligence in education and their educational benefits and the second seeks to specify among these applications those represent a trend in scientific research.

According to the bibliometric analysis carried out, we found that there are three paradigms in AIED. The first (AI-Directed, learner-as-recipient) treats the user as a consumer of AI services, which are typically utilized to represent knowledge

models and direct cognitive learning. The second (AI-Supported, learner-as-collaborator) attempts to create a kind of collaboration between the learner and the AI, i.e. the latter is used to support learning. The third (AI-Empowered, learner as leader) aims to increase human intelligence. This paradigm which, puts the learner at the heart of the teaching-learning process, aims to:

- Implement full cooperation between human and machine (Conversational intelligent agents, Virtual learning environments, Intelligent tutoring system)
- Provide personalized/adaptive learning (Adaptive learning systems, Recommendation systems, Expert systems)
- Generate real-time information on learning etc.

Using AI techniques such as:

- Machine learning (Supervised and Unsupervised)
- Deep learning
- Artificial neural networks

Is the most requested in term for scientific research, in other words, this paradigm illustrates the development trend of AIED [44].

In our future research, we aim to approach the sphere of adaptive learning systems or environments, since it represents a trend of AIED technology, in addition to the assessment assisted by AI because we have noticed that it excites little 'studies even if it represents one of the ultimate objectives as mentioned at the beginning of our present paper.

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