SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 4, (2026), pp. 9692-9705
Open Access. Online & Print

DOI: 10.5281/zenodo.12426948

4A BIBLIOMETRIC ANALYSIS OF THE ROLE OF ARTIFICIAL INTELLIGENCE IN ADVANCING THE EDUCATIONAL AND PEDAGOGICAL PROCESS TOWARD SUSTAINABLE SMART EDUCATION

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Received: **22/11/2025**
Accepted: **22/03/2026**

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Abstract

Background/purpose. This paper is a detailed bibliometric analysis of the academic research on the role of Artificial Intelligence (AI) in enhancing the educational and pedagogical process to a sustainable smart education. The study also analyzes the trends of publications, the authors and institutions who have had the most impact, the prominent thematic groups, and worldwide collaboration patterns using data gathered into the Scopus database in the period 2014-2024 (n = 3,850). **Materials/methods**. According to descriptive performance indicators, the research in AI-in-education is rapidly increasing, especially since 2020, due to the appearance of intelligent tutoring systems, personalized learning technologies, and learning analytics. Science mapping visualizations such as co-authorship, co-citation, keyword co-occurrence networks and thematic mapping demonstrate three research clusters that are predominant: (1) pedagogical applications and personalized learning, (2) ethical challenges and equity issues, and (3) AI-driven educational management and automated assessment. **Results**. The strategic diagram also forms motor themes, which constitute the field actively, and niche themes, which are internally formed but have no centrality, foundational basic themes, and emergent topics, including quantum education and learning in the metaverse. **Conclusion**. On the whole, the results indicate that AI has the transformative power of personalized learning, improved assessment, and decision-making, as well as facilitated inclusive education, but also demonstrate that the issues of data privacy, algorithmic bias, institutional preparedness, and digital inequality are still present. In order to enhance safe, ethical and effective use of AI technologies in education, the study suggests enhanced teacher training, investing in digital infrastructure and instituting AI policies at the national level.

1. Introduction

Artificial Intelligence (AI) can be viewed as one of the most dramatic changes in the domain of modern technology. It is based on the use of high technology with the intention of increasing the efficiency of the institution and bettering performance through facilitating the decision-making process. It is significant because it has the ability to come up with new management strategies in different fields and at different levels.

AI is viewed as an arm of computer science that aims to model the human behavior and is thus able to make machines think as human cognition.
The uses of AI have become a strategic need among different countries that aim at building the educational systems. This industry is still in need of basic restructuring, which can be achieved by investing in the technologies as a viable solution

to solving educational issues and offering a safe and high-quality learning environment.
The given study was launched to find out the purpose of using AI technologies in the educational process, examine their pedagogical effects, and determine the most significant issues related to the usage of AI technologies in the educational sphere.

Research Problem
This study is relevant due to the growing influence, widespread usage, and fast internalization of the AI application in different aspects of the educational process. The issue about the research is that it is necessary to clarify the most noticeable AI applications which can be used in education, evaluate the implications of their use, and identify the obstacles which hinder their use in the educational setting.
Based on this, the following questions may be put across to formulate the research problem:
1. What are the most noticeable examples of Artificial Intelligence applied in the educational process?
2. What are the effects of the Artificial Intelligence application to the learning process?
3. What are the obstacles that prevent the usage of Artificial Intelligence applications in the field of education?

Significance of the Study
The relevance of the study is explained by the increased role of AI apps in creating education and enhancing its performance. The importance of it can be summarized as the following points:
1. To explain the overall picture of the use of AI applications in the educational process, their contribution to the facilitation of educational and learning activities, and the problems that the users are likely to encounter.
1. To determine the key AI applications and the ways of their implementation in the educational sector.
2. To help the decision-makers in the educational institution to make the most appropriate choices using AI applications under consideration of the needs and requirements of the educational environment.

Objectives of the Study
The following are the key objectives of this study:
1. To determine the most striking examples of AI use that can be utilized in the learning process.
2. To clarify the expected effects of the application of AI applications in creating the educational process.
3. To outline the main issues that can potentially face the utilization of AI applications in the education field.

Definition of Terms
Artificial Intelligence (Linguistic Definition): Capability to analyze, synthesize, differentiate and test (Arabic Language Academy, 2004).
Artificial Intelligence (Operational Definition): It is a contemporary science that deals with creation of systems, devices, and software capable of replicating the cognitive functions in human beings including thought, decision-making, and problem-solving. This science is based on the combination of hardware and software technologies in computers to execute functions that are similar to human intelligence in the analysis, inference, and learning (Ja'wani and Al Ka'bi, 2024).
The Educational Process: Educational process is characterized as a complex of planned and coordinated procedures and activities, which aims at satisfying the educational needs under the objectives and policies of the state higher education. It is built on such foundational theories as science, humanism, and democracy and attempts to equip the learner with skills and knowledge that allow them to improve their personal performance and increase their prospects in the labor market (Jaber, 2018).

2. Literature Review
(Al-Sharif & Farid, 2024) ,The objective of the study was to establish how the use of artificial intelligence applications in the teaching of the course "Educational Technology" took place. This was done by investigating the effect of their use in enhancing cognitive performance and acquisition of technical skills among 4 th year undergraduate students of the Mathematics Education branch of the Faculty of Education, Minia University in the 2 nd semester of the 2022/2023 academic year. The experimental group involved 109 male and female students that were randomly picked and given one experimental group. The researcher used quasi-experimental study design with pre-test/ post-test to estimate the effect of the independent variable (AI applications in teaching Educational Technology course) on the two dependent

variables (cognitive achievement and technical skills). Such data collection tools as a cognitive achievement test and a scale were used to assess technical skills. The findings showed that the application of AI applications in teaching the course positively influences the ways students improve their cognitive levels and acquire technical skills. The research indicated the need to educate faculty and students about the application of AI applications in academic classes and their use in more courses and especially in teaching technical and mathematical skills.

(Khanafis, 2024) ,This research was meant to anchor Artificial Intelligence tools as a key component of the learning process. Many of the teachers have taken advantage of these technologies to enhance their performance by saving on time and energy, honing their teaching skills, enhancing efficiency, and dealing with diversity among learners. On the contrary, not all teachers can cope with such a technological change, which also presents an issue with the gap in the quality of educational performance related to the level of digital transformation of teachers and their use of the tools of AI, which, in turn, further influences the education system in general. Against this backdrop, the research was done to confirm the hypotheses about how the digital transformation skills affect pedagogical performance by taking the descriptive survey approach and the data collection instrument was a questionnaire based on a sample of the teachers in the private schools of Beirut.

(Abu Mokadem, 2024), The study will seek to establish the levels of artificial intelligence application use in self-directed learning among graduate students in Jordanian higher education institutions. The research took the descriptive analytical research design and relied on a questionnaire as a major instrument of collection of data after verifying its reliability and validity. The tool was used on a sample of 452 male and female graduate students in the first semester of 2023/2024 in Jordanian Universities. The findings showed that the level of self-directed learning based on the use of AI applications was high. It also showed that there was a high positive relationship between self-directed learning and usage of AI applications. Also, the results revealed statistically significant differences in the degree of applying the ChatGPT AI application in the process of self-directed learning between graduate students, based on the type of university (public or private), but not based on the level of academic qualification (PhD, Master, Higher Diploma). With respect to the results, the study prescribed the necessity of creating the university courses that would help to better integrate the AI application in scientific studies, and get graduate students to learn to utilize the applications as the proper motivators of fostering the self-directed learning and acquiring the skills of conducting scientific research.

Al-Mutairi (2019) The purpose of this research was to determine the weaknesses of the implementation of artificial intelligence technologies as a method of creating a decision-making process in the State of Kuwait. In the study, 56 educational leaders who work at the Kuwait Ministry of Education were taken as the study sample. The research followed the descriptive approach and employed one of the methods of future research, which is the Delphi technique, to question the opinions of experts. The findings showed a number of deficiencies, the most evident of them being the deficit of training of educational leaders on the use of AI in the decision-making process, the insufficient use of smart technologies in the decision-making process in educational institutions, and the inclination to use the traditional approach to the problem, as well as the insufficient preparation of the staff in the given sphere. Another shortage identified by the study was the lack of intelligent databases that should be used to facilitate the making of decisions in the field of education and the lack of awareness amongst the personnel on the significance of AI in the creation of educational administration.

(Aurn, Hs, & Kumar, 2023),The purpose of the study was to find how artificial intelligence applications influence self-directed learning in higher education students (Kuleto, Llic, Dumangiu, and Mihoreanu, 2023). A sample of 103 males and females students of several universities participated in the study and they were selected randomly. The research involved the use of various measuring instruments to determine the degree of self-directed learning and AI application skills. The findings indicated that there was a significant positive effect of using AI technologies to the self-directed learning of the students. The students also showed a difference in the levels of attaining technical skills.

(Teo, 2022),The proposed study will seek to address the possibilities of using the artificial intelligence tool, ChatGPT, in online higher education. The paper was aimed at testing the capacity of ChatGPT to differentiate between the text, which it writes, and human-written texts. The research was a comparison of the output of ChatGPT to the human writings on quality of writing and critical analysis. These findings suggested that ChatGPT has a high potential of

generating advanced writing; but this also creates academic issues of security and integrity in online exams, especially in educational institutions of higher learning.

Review of Previous Studies

As shown in previous Arab and non-Arab research, there is an increasing interest in adopting applications of artificial intelligence in the educational field, as well as, higher education, not only in improving administrative performance and decision-making, but also in promoting self-directed learning and cognitive performance in students.

In one of the Arab studies, Al-Mutairi (2019) found a substantial gap in the implementation of AI in educational decision-making, which determined training educational leaders and qualifying staff and the provision of intelligent databases. This shows the lack of digital infrastructure and institutional sensitivity to artificial intelligence. On the same note, the article by Al-Sharif and Farid (2024) has demonstrated effects of application of AI in fostering cognitive achievement and technical skills in students in the Faculty of Education, which validates the need to train students on how to utilize the applications in academic studies. The study of Khanafis (2024) found that AI tools have helped to enhance teacher performance, and there was a gap between obtaining digital skills, which explains why the teacher competencies need to be developed on a continuous basis. Moreover, the article by Abu Mokadem (2024) demonstrated that AI tools such as ChatGPT can result in self-directed learning in graduate students, though the kind of university has an impact on the extent to which AI applications are used, but academic qualification does not.

The international research, in its turn, was aimed at the effects of AI on self-directed studies, as well as the creation of academic materials. The researchers suggested that the use of AI applications by higher education students positively influences the self-directed learning process, and the difference in acquiring technical skills was observed (Kuleto et al., 2023). In the meantime, the article by Aurn, Hs, and Kumar (2023) emphasized the ability of ChatGPT to write high-quality academic papers, including in terms of style, quality, or accuracy, but requiring a human review to verify the relevance of the information. The research by Teo (2022) has shown that there is a possibility of the ChatGPT to distinguish between machine-generated and human-written text, with the author indicating the problem of academic dishonesty and safety in online testing.

Having analyzed these studies, it is possible to make a conclusion that artificial intelligence is a strong factor in the formation of the educational process, self-directed learning, and cognitive performance. Nevertheless, gaps in the context of digital infrastructure, the degree of training of teachers and students, and academic integrity with the help of technologies like ChatGPT can be observed. This highlights the necessity of having additional local research to assess the effects of these applications in certain settings, as well as, determining the obstacles and opportunities to enhance the quality of education and learning efficacy.

Theoretical Framework

Artificial Intelligence

Artificial Intelligence (AI) is a sub-discipline of modern computer science that can be described as one of the core pillars of the modern technological revolution.

This area of study works to create hardware and software that can replicate human thought and also make intelligent decisions based on the systems that are incorporated into the computer to carry out the activities that mimic the human intelligence. The modern technologies have introduced a major revolution in the world in different spheres of life and education has had its fair portion of the revolution. AI has been used in coming up with intelligent educational tools of precision, speed of performance, and interaction with learners. The world has been interested in adopting these applications because of the potential they hold in enhancing quality of education, self directed learning processes, and in aiding the teachers to come up with more effective learning environments.

According to numerous scholars, AI is one of the most valuable technical strategies aimed to create the educational process, examining the needs of students, personalizing the instructional process, and measuring academic success of students using accurate scientific techniques. What is more, AI has a unique ability to solve problems and make the right choice in a way that is similar to the human thought (Shams, 2020). The ability of a machine to mimic the human mind and its ways of operation, including its ability to think and explore, as well as to perform tasks that require exploring and establishing theories with great skills and efficiency, is what it is (Institute of Banking Studies, 2021).

Characteristics of Artificial Intelligence

The AI has a series of features that endow it with the power to think and analyze and allow it to help

learners gain knowledge, comprehend facts, and obtain relevant information. It also helps to interpret data and use the results in new ways to complete various tasks, and make the right decisions to new situations in life, using the collected and analysed data. Therefore, AI is regarded as a viable way to improve the mental and creative abilities of humans in the context of changing circumstances (Holmes, 2022).

The Importance of Artificial Intelligence

The significance of Artificial Intelligence cannot be overestimated by the current generation because it plays a significant role in the creation of different spheres of life, increasing the effectiveness and efficiency of the latter especially the educational field. As noted by the International Society of Technology in Education (2020), the importance of AI is reflected in various ways, the first of them being the personalization of education. The discipline allows a student to learn individually using intelligent learning designs that can identify their behavior and discern their educational requirements. This is due to the ability to provide custom content and educational technologies that can be relevant to their capabilities and interests and to help create a more efficient and effective learning process. The role of AI can be specifically noted in the field of individualizing education:

Personalization of Education

Artificial Intelligence helps in offering personalized learning to students through proper analysis of their behavior and comprehending their learning requirements. These technologies provide an opportunity to customize the educational material to the level and skills of each student, which contributes to the higher learning results and the increase of the educational process efficiency. Another opportunity that this sphere provides is the possibility to offer smart educational means that can promote the current learning strategies and help to create a more interactive and reconfigurating learning environment. Moreover, AI plays a great role in shaping the educational process because it provides students with personal learning experiences that address the needs of individual students.

Through the performance and response of the learners in the course of learning, AI systems are able to adjust learning materials and the mode of teaching to suit the abilities of the learners as well as their learning rate. These systems also help in a proper assessment of the performance of the students, their strengths and weaknesses and help in giving recommendations to the content and instruction methods to ensure that the education mode is in tandem with the current needs. They also provide intelligent educational products that facilitate learners with special needs and enhance the quality of education by providing instant interaction between the student and the teacher.

Through educational data, especially the large-scale data, AI can offer immediate feedback and guidance to the learners in the learning process, enabling the teacher to track the academic progress more effectively and faster. Recent signals have indicated positively that AI applications have a clear role of enhancing the quality of education and providing a more inclusive and efficient learning process in the different educational institutions (Bab for Strategic Studies, 2023).

Providing Educational Resources

The analysis of the educational data of the students and the precise definition of their level of progress by AI will help in the customization of the educational process based on their needs. It is possible to tailor the educational content to each of the students to the abilities they have so that it improves their understanding, helps them develop their skills and brings better learning results.

Enhancing Interaction

The process of interaction between learning material and a student can be effectively and innovatively improved through the use of AI that facilitates the interactive mode of learning and makes the student want to participate in it constantly. It also assists in the various learning styles, a deeper comprehension and interpretation of learning content and it promotes critical thinking and problem solving among the learners (Farah, 2020).

Achieving Equity

There are several opportunities that AI technologies present to create a rich learning environment, interactive activities, and development of the thinking skills of students. They allow the learners to think critically about the educational content and information, work on analyzing and comparing various ideas and concepts, and putting them into different practical applications. The technologies also assist the processes of strategic planning and self assessment that helps to cultivate the skill of making evidence based decisions based on credible information. In addition, AI systems assist in bridging the gap between students and knowledge in a regulated and systematic way and access to educational

content, which also promotes interactivity and self-directed learning (Muyassar, 2021).

In this regard, it is seen that AI will help to promote education through allowing learners to combine information and knowledge and apply it efficiently, and by linking various elements of learning in a unified way. It makes the best use of learning resources and improves the learning of the necessary skills in the most efficient way (Al-Muqaddi, 2020).

Applications of Artificial Intelligence in Education

Computer usage in education and learning has experienced an enormous evolution, both in the eyes of the students as well as the experts and stakeholders of the learning process, which include teacher, instructional designer as well as curriculum developers. The artificial intelligence applications in the educational field can be broadly classified using parallels with the traditional use of computers in the educational process as follow:

- As a tool for teaching and learning.
- As a subject matter.
- Educational administration.
- For assessment purposes.
- Support for students with special needs.
- Other applications.

The Use of Artificial Intelligence as a Tool for Teaching and Learning

AI has been applied as a teaching and learning aid in improving the process of teaching and learning by using its potential and programs to complete diverse education and training tasks. As an example, students can solve problems with the help of expert systems, practice to cope with certain skills, and learn the sequence of thought and reasoning related to certain educational goals.

One of the most recognizable practical uses of AI in education is the so-called Intelligent Tutoring Systems (ITS) based on AI. Their individual learning environment enables them to deliver education content in a personalized way, based on the needs of each learner and they are beneficial in heightening interaction with students of the learning content.

This model is also advantageous to teachers and educational stakeholders, in which the teacher or subject matter expert learns the AI languages or intelligent authoring system in order to create expert systems or intelligent tutoring programs to help him or her teach a given topic or curriculum to students in a more effective way (Faraj and Muhammad, 2023).

The Use of Artificial Intelligence as a Subject Matter

This model can be defined as the learning of AI science by school and university students, whereby AI becomes a course of study, as a topic on which the student is learning. In this manner, students can learn the concepts of AI and the different fields, as well as know its programming languages including Lisp, Prolog, and CLIPS, which would help them to create expert systems in any domain related to the topic of study (Mahdi, 2023).

The Use of Artificial Intelligence in Educational Administration

This model will seek to harness the abilities and services offered by AI to carry out the high-level administrative tasks that are challenging to fulfill through the conventional approach in the computer systems and therefore help in enhancing the efficiency of administration and precision of the administrative activities within the institutions of learning.

One of the most noticeable uses in this field is the expert systems, which could be utilized to make the complicated administrative decision-making tasks highly efficient. As an example, such systems are able to design and allocate class schedules automatically when information pertaining to classrooms, teachers, number of students and their division is offered. They may also be utilized in the form of educational and diagnostic decision-making with reference to students which involves assessing their performance, offering proper judgments of their academic levels, and carrying out non-traditional tests using advanced patterns and questions that correspond to the abilities of the students. Moreover, it is possible to utilize other AI tools like machine translators, and voice and speech recognition systems to enter voice data, as well as other various educational applications that help to enhance the quality and maximize the efficiency of the educational process (Al-Sayed, 2024).

The Use of Artificial Intelligence for Assessment Purposes

Conventional assessment and examinations, as many of them are based on one test to measure student performance, may result in an incorrect and unjust analysis of the individual skills. Those technologies provide the possibility to design more flexible and innovative tests that are oriented on the creativity and multiplicity of skills of students instead of being limited to rote memorization and recall.

There is a tendency towards more holistic and objective assessment, and certain universities are already trying to change their assessment practices to incorporate some innovation and creativity in assessing student capacity. Moreover, conventional systems especially through essay examinations demand a high load to the teachers when it comes to grading a huge number of answers per year.

In this case, AI will be able to mark a significant part of these tests with high precision, examining words and learning patterns. Such systems also help eliminate personal differences among the learners by offering precise and customized evaluation to each student, and they lessen a large percentage of their administrative burden and leave the teachers with the opportunity to concentrate on research and studies. At the university level, it translates to more attention to scientific research and attendance in conferences, and AI systems lower operating expenses, especially in state-run universities, which will lead to an increment in the number of available university and institute seats (Salah, 2023).

Supporting Students with Special Needs through Artificial Intelligence

AI systems have been found to be effective in assisting students with disabilities by availing them with specialized education to meet their various educational requirements. As an example, they may help students who have visual or hearing impairments, or who experience difficulties with social, language and communication skills to enjoy an improved educational process.

Wearable computers and artificial intelligent (AI) programs are implemented to help students with disabilities read books, recognize faces, and socialize, which help to integrate students with disabilities in the educational and social settings. Moreover, there are targeted systems being designed to assist students with all kinds of disability such as physical and health disability and mental health issues. The combination of AI with augmented reality, virtual reality, and robotics helps improve the learning process of such students to provide them with a secure and adaptive learning environment that can help them to produce the highest academic and social results (Al-Sayed, 2024).

Other Applications of Artificial Intelligence in Education

AI has seen many applications emerge that are using its ability to make pattern matching and give a personalized recommendation to students, teachers and parents. Some of the most notable of such applications are:

1. Online and Blended Learning: In online and blended learning, AI-based chatbots offer real-time data on classroom activity to both students and teachers, and other sensors and cameras measure the activity of students and their interactions in the classroom. Feedback and tailored recommendations are then given to the teachers to enable them to enhance the quality of learning and guide students better.

2. Foreign Language Learning: Speech recognition, text analysis, and pronunciation correction are among the functionalities of AI that assist the teacher teaching a foreign language, thus improving the process of language acquisition by the students in a more efficient way. All these applications will lead to the improvement of the quality of education on the global level, bringing constant support and accurate feedback both to teachers and learners. One of the possible ways to address the needs of various educational groups is also to use them in different contexts (Ahmed, 2020). One can argue that recent advancements in technology, especially in Artificial Intelligence, have caused the absolute revolution of the education sector over the last few years. It is possible to implement the experience of teachers and educators intelligently with the help of AI applications to enhance the educational process because educational devices and software can determine the necessary knowledge and skills on the fly and automatically modify lessons according to the needs and abilities of the students. In addition, such applications enable improved and convenient curriculum development and updating as opposed to traditional methods that may take decades.

The Impacts of Using Artificial Intelligence Applications in the Educational Process

The teacher is a central pillar of the educational process development that has the responsibility to follow the speed of changes in the educational and technological aspects. Along with the rise of the Artificial Intelligence, teachers have become obliged to take new roles that comply with the demands of the digital revolution and the needs of modern education, becoming curriculum developers and learning process facilitators. This is what their role is in the era of artificial intelligence (Hindi, 2020). Artificial Intelligence has helped in a qualitative advance in education. It combines computer science and information technology on the one hand, the learning sciences on the other, and seeks to make a better understanding of both

teachers and learners about the mechanics of learning, as well as what affects it. This helps in making education smarter and more powerful due to the use of data and smart systems to inform educational choices. The significance of this transformation is not denied by many countries, and they are aiming at developing the teaching strategies with the help of smart technologies to become more competitive in sciences and technologies all over the world. Moreover, AI can provide teachers and administrators with new opportunities to make the work easier by offering innovative solutions to classroom and organizational dilemmas. According to Mekawi (2018), AI applications are useful in diagnosing and resolving learning challenges, giving feedback to learners, and maintaining quality education to everyone with the help of educational robots and simulation systems. Scholars have concurred on the fact that Artificial Intelligence is one of the cornerstones in modern education because of its various functionalities that include:

- Self-directed learning and so-called knowledge organization.
- Speech, pictorial and video comprehension and analysis of language.
- Robot actuation, emotional and social interaction.
- Instant feedback and explanations of education.

Also, AI can be effectively used in the educational administration, including answering the parents questions, organizing the registration process, and tracing the lessons with the help of AI-driven chatbots. It will also help in enhancing the quality of education and skills of teachers and administrators and therefore, investment in it will be a strategic requirement in the next few years. The usage of AI has resulted in a complete change in the learning process. It has allowed customizing education based on the requirements of each student by processing big data, determining learning patterns and understanding levels to empower a teacher to teach a personalized content and learning experience (Al-Mahdi, 2021). The AI has also assisted in alleviating the administrative pressure on teachers since it automates most of the routine work, including electronic assessment, performance measurement, and scheduling classes based on the abilities and interests of teachers. Moreover, it helps to reveal gifted students or those with learning issues and support each of them on a necessary basis (Al-Ali et al., 2009). The smart applications have also freed the learners of the conventional model of education as the digital platform provides lessons that are tailored to the interest and needs of students. The AI software offers the chances of self-directed learning, which is continuous, self-correction, logical interaction, and complex problem-solving in systematic and scientific ways. Moreover, AI provides much help to the disabled people that have a text-to-speech or speech-to-text technology, which helps them to become an additional part of the learning process and enable them to enjoy the advantages of information and communication technology. Thus, AI applications can be a qualitative supplement to the advancement of the educational process and enhancement of the results. They do this by increasing the efficiency of learning, facilitating one-on-one learning, and raising the skills of the teachers, which culminates into the invention of a smart learning environment that is founded on innovation and a constant interaction.

Challenges Facing Artificial Intelligence

1. Teacher Resistance and Institutional Readiness Teacher resistance to the use of technology, their distrust of AI tools, and teaching methods changes are some of the most eminent issues. Likewise, this dismays institutional readiness, in terms of infrastructure, human resources, and training, which causes the slow or unsuccessful incorporation of these technologies (Arriazu, 2024).
2. Ethical Issues, Privacy, and Algorithmic Bias This group of issues is related to the safety of student data, algorithmic fairness, and transparency of operations implemented by the systems. It also features the threats of bias, discrimination, or violation of academic integrity due to excessive use of AI (Mauti and Ayieko, 2025).
3. Reduced Human Interaction, Over-reliance, and a Decrease in Creative Thinking Although AI systems enhance tailored learning, these systems might decrease the possibility of human interaction, consequently impacting communication and creative abilities of students. They can also contribute to the over-dependence on the machine, rather than on thinking (Yan, L., Sha, L., Zhao, L., et al., 2023).
4. Digital Divide, Technical Resources, and Talent needed to Develop and use AI in education would need well-developed technical infrastructure, access to high-performing internet, trained teachers and trainers, and adequate funds. The problem of successful AI integration is aggravated in the context of the lack of such resources in certain institutions or regions (Mereke, 2024).
5. Scientific, Ethical, and Technical The scientific viewpoint entails an issue of confirming the correctness of the information and sources used by

AI that might result in the spread of false or misinformed information (Yan et al., 2023).

Technically, it requires high-quality infrastructure to effectively run AI systems efficiently, such as high-level hardware and software to handle and analyze large amounts of data and do it correctly. Another difficulty here is the creation of systems that can support individual differences among learners and customize education based on their needs and abilities (Cui and Alias, 2024). Ethically and socially, one can be concerned about the privacy and data privacy as such systems are based on the idea of gathering vast quantities of personal data about students and teachers. More than that, the growing use of AI poses the risks associated with the loss of direct communication between the human factor and the educational process and the necessity to oversee the quality of choices made by the systems to guarantee the effective accomplishment of educational objectives (Pavlik, 2023). Hence, to apply AI to the educational process, it is essential to design combined measures to solve these issues, such as improving the technical infrastructure, guaranteeing the quality of information, securing data, and paying attention to the role of the teacher in the facilitation of the responsible and efficient use of the technologies.

Challenges and Opportunities Associated with Using AI in Education

Studies indicate that AI applications in education face multiple challenges related to technical, regulatory, social, and ethical aspects. On the technical front, researchers note the difficulty in ensuring the accuracy of the information and sources relied upon by AI, which may lead to providing incorrect or misleading information to both learners and teachers (Zawacki-Richter, 2019). Additionally, there is a need for robust infrastructure to support intelligent systems, including advanced computers and software capable of analyzing big data and producing customized educational solutions for each student. From a regulatory and social standpoint, integrating AI into education requires preparing a suitable educational environment that includes designing educational policies, regulating data, and providing appropriate training for teachers and specialists. This also involves creating plans to manage individual differences among students and achieve equity in learning opportunities (UNESCO, 2021). Adherence to ethical standards and the protection of student and teacher privacy are among the most significant accompanying challenges, especially when using tools that rely on the collection and analysis of personal data.

Among the major challenges that AI must address in the educational field, as noted by Woolf (2023), are the following:

1. A virtual tutor for every learner: Providing personal support that combines learner behavior modeling, social simulation, and knowledge representation to ensure an integrated learning experience.
2. Providing opportunities for global classrooms: Enhancing connectivity and easy access to classrooms worldwide, thereby broadening learning horizons and enabling cultural and knowledge exchange.
3. Lifelong learning technologies: Moving learning beyond the classroom to become part of the learner's daily life, thereby promoting continuity and the practical application of acquired skills.
4. Interaction data analytics: Collecting and analyzing large amounts of data related to individual learning styles, social contexts, and student interests to design personalized learning experiences.

Keeping pace with 21st-century skills: Supporting learners in developing skills for self-direction, self-assessment, teamwork, and critical thinking, in line with the demands of the modern era.

On the other hand, Mekawi (2018) pointed to some practical difficulties facing the application of AI in education, most notably:

1. A shortage of specialized educational personnel in information technology within schools.
2. The difficulty for teachers to meet the diverse educational needs of students individually.
3. The challenge of achieving deep learning and developing non-cognitive skills in parallel with mastering traditional cognitive content.

Collectively, these challenges indicate that adopting AI in education requires strategic planning, continuous teacher training, and integrated institutional support to ensure the realization of desired benefits and the improvement of the educational process's quality.

Despite these challenges, AI applications offer significant opportunities to enhance the quality of education, such as supporting personalized learning, improving teaching outcomes, and facilitating the tracking of student performance. They also enable teachers to focus on curriculum development and scientific research rather than being occupied with routine tasks (UNESCO, 2021). Furthermore, these applications can reduce disparities among learners and provide broader access to education, particularly in environments suffering from a shortage of educational resources.

3. Methodology

This paper has used bibliometric mapping to critically guide the intellectual framework, conceptual development, and research directions of the educational process within Artificial Intelligence (AI). Bibliometrics represents a serious quantitative method in the analysis of a significant amount of scientific literature, allowing to determine the trends of publications, the most active people, and networks of collaboration and around the studied topic (Aria and Cuccurullo, 2017; Zawacki-Richter et al., 2020). The methodological framework of the current research is divided into three consecutive actions, i.e. data collection, data analysis and performance evaluation.

Data Collection and Search Strategy

The information used in this analysis has been obtained in the Scopus database on May 15, 2024. Scopus was chosen because of the fact that it has a wide coverage of peer-reviewed literature, powerful search tools, and provides comprehensive citation tracking features. A carefully designed search string with a high level of relevant and comprehensive search was applied, which included key words related to AI and education:

- TITLE-ABS-KEY ((@Artificial Intelligence OR AI OR Deep Learning OR Machine Learning) AND (Education OR Pedagogy OR Learning OR Teaching OR Educational Process).
- In order to assure the quality and focus of the dataset, special inclusion and exclusion criteria were used:

1) Period: 2014-2024, to get the latest decade of the research and the recent explosion of interest after the release of generative AI.
2) Type of document: Articles and Review Articles only.
3) Language: English.
4) Subject Area: Trained on the topics of Social Sciences and Computer Science in order to eliminate literature related to unrelated topics.
5) The initial search had 4,580 documents. A screening of titles and abstracts to eliminate irrelevant publications resulted in a final dataset of 3,850 documents which was exported in CSV format to be analyzed.

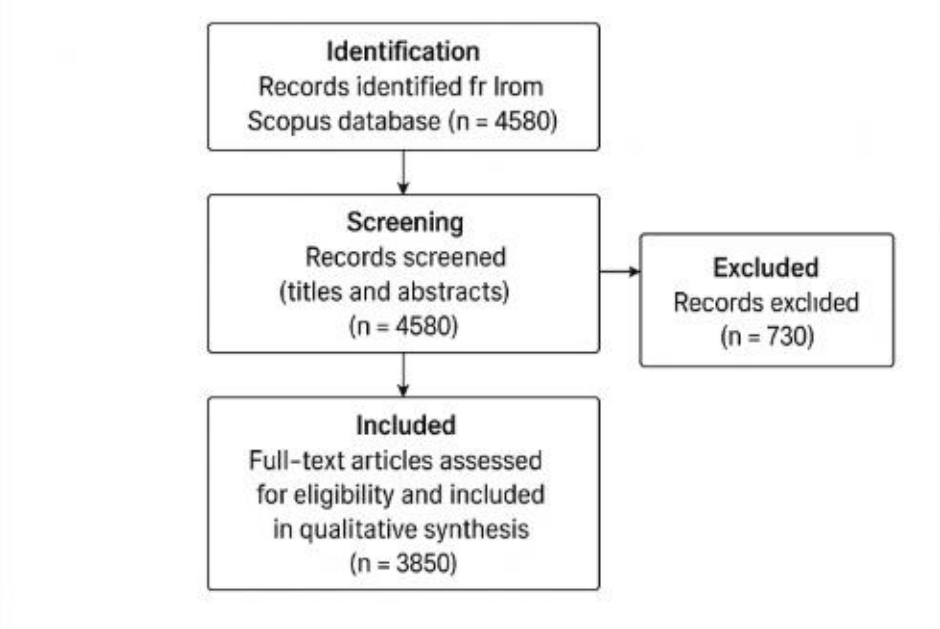

Figure 1. PRISMA Flow Diagram of the Study Selection Process

Data Analysis and Tools

The dataset of the exported data, including the information about the authors, affiliations, keywords, abstracts, and the number of the citation, was examined with the help of a combination of two specific bibliometric tools:

- Biblioshiny: An open-source web app that offers a simple interface to numerous bibliometric and science mapping visualizations (Aria and Cuccurullo, 2017). It was employed in descriptive statistical analysis, such as publication patterns, most prolific sources, authors and institutions.
- VOSviewer (version 1.6.19): The program is a software that was created by Leiden University in order to create and visualize bibliometric networks (van Eck and Waltman, 2010). Network maps were generated mostly using VOSviewer on the analysis

of co-authorship, co-citation and keyword co-occurrence.

Bibliometric Indicators and Measures

Three fundamental dimensions were used to analyze the field of research to give an overview of it holistically:

- Performance Analysis: This aspect was assessing the scientific output and influence of the area of investigation. Key indicators included:

o Annual Scientific Production: Annually produced number of publications.

o Source Impact: Best journals according to the number of publications and citation (e.g., Scimago Journal Rank - SJR).

o Author Impact: Most cited and most productive authors.

o Country/Institution Contribution: Publication and foreign publications and international publications.

- Science Mapping This dimension represented structural and dynamic connections in the

- literature. The network analyses conducted were the following:

o Co-authorship Network: To determine the pattern of collaboration between countries, institutions and authors.

o Keyword Co-occurrence Network: Keyword Co-occurrence Network will be used to determine the most significant research topics, the relationships among them, and their development through time.

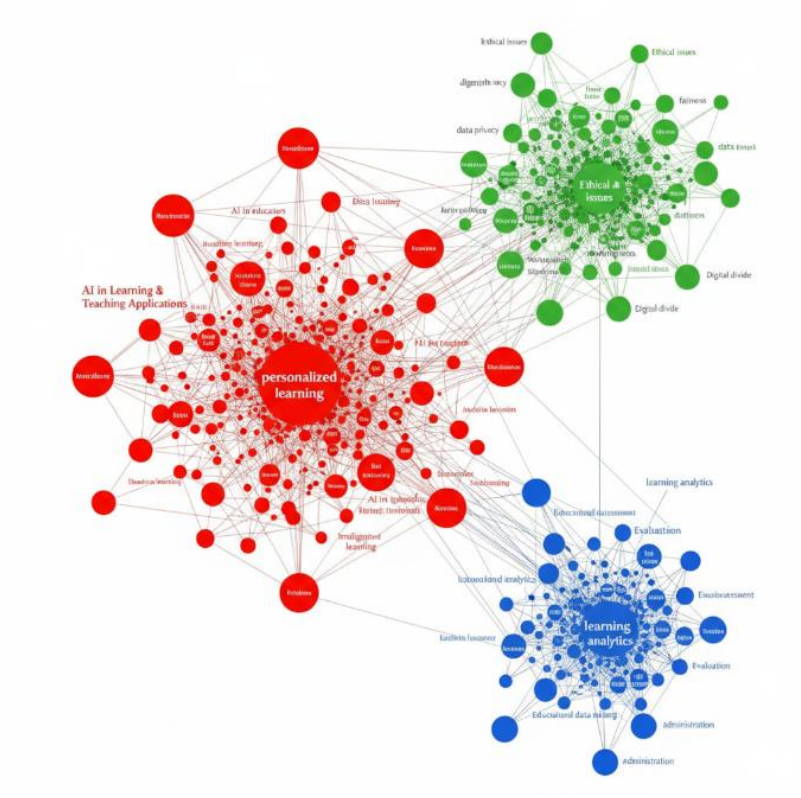

Figure 2. Keyword Co-occurrence Network Map

The visualization of the network map in Figure 2 and the keywords presented as a co-occurrence analysis identified 100 keywords with the minimum count of occurrence being 50 times. The network unveiled the intellectual form of the discipline, constituting itself around three different and notable thematic resolutions:

- Cluster 1 (Red): Personalized Learning and Pedagogical Applications. It is the most central and largest cluster, which includes key words: personalized learning (total link strength: 850), intelligent tutoring systems (710), student engagement (680), educational technology (650) and learning outcomes (620). This group represents the main interest of the literature devoted to the ways of how AI can revolutionize the teaching and learning processes, by customizing the education process according to the needs of individual students. The high levels of critical thinking and 21 st Century skills in this cluster are consistent with the results of the beneficial pedagogical effects of AI.

- Cluster 2 (Green): Ethics, Challenges and Equity. This cluster will touch upon the criticalquestions and obstacles on AI implementation. Such phrases as ethical issues (590), data privacy (560), algorithmic bias (480), digital divide (450), teacher training (440), and

academic integrity (410) are key. This topical focus is directly associated with the issues outlined in the literature, which presents extensive concerns about fairness, security and institutional preparedness and professional growth.

- Cluster 3 (Blue): AI in Educational Management and Assessment. The administrative and evaluative uses of AI are the target of this cluster. It contains such keywords as learning analytics (520), educational data mining (490), automated assessment (470), decision making (440), and smart education (420). This theme contributes to the discussion of the literature regarding the way AI simplifies the administration process and advances the assessment tool, leaving educators with more innovative and high-impact activities.

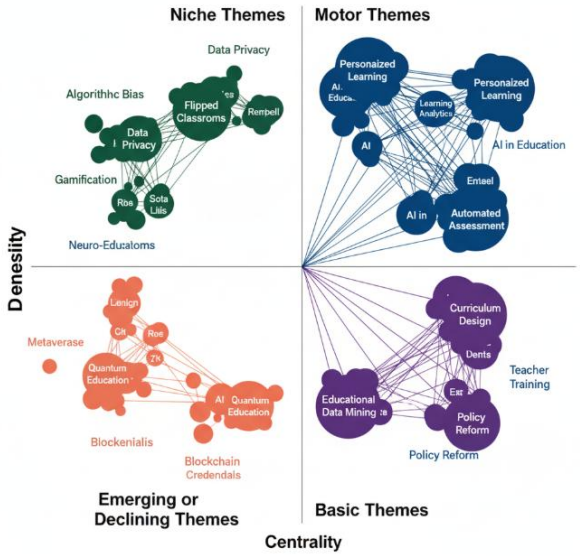

Figure 3. Strategic Diagram of Thematic Evolution

Thematic Evolution: A strategic diagram was produced to visualize the thematic development of the field mapping themes by their development (density) and relevance (centrality) to clearly identify emerging, niche, and motor-themes. Figure (3) is a thematic map that shows the strategic location of research themes in AI and education were four quadrants were created using centrality and density. Motor Themes are highly developed and powerful themes which are personalized learning and learning analytics. Other niche themes such as data privacy and flipped classrooms are quite advanced but not more central to the field. There is a cornerstone of the domain comprising of Basic Themes, i.e. educational data mining and curriculum design. Themes Emerging or Declining such as quantum education and the metaverse are either developing or becoming irrelevant. All in all, the map seems to be a brief representation of the thematic framework of the field and its possible future trajectory.

- International Collaboration Network: To visualize the global research landscape, a network map of country co-authorships was created.

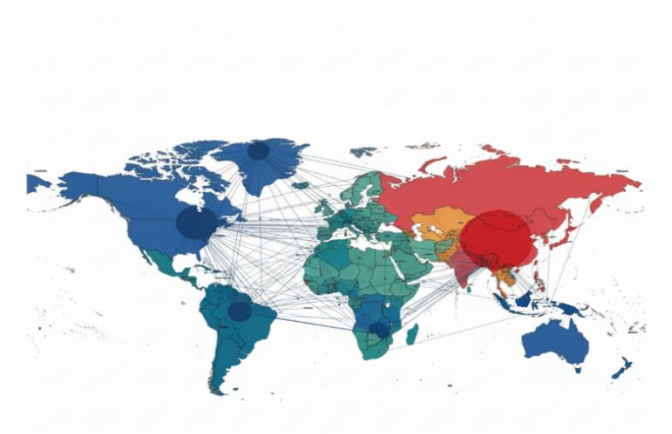

Figure 4. International Collaboration Network Map

5. Conclusion

This bibliometric paper gives us a sufficient understanding of the scientific environment of the application of Artificial Intelligence in the educational and pedagogical process. The study is based on the analysis of 3,850 publications indexed in Scopus during the last decade, which proves the idea that AI has been transformed from a facilitating technological service to one of the key drivers of educational innovation. The results proving the fact that the focus of research has moved towards individualized learning, learning analytics, automated assessment and automated decision support systems based on AI have become the driving power themes of the discipline.

Meanwhile, the analysis indicates that there are persistent difficulties related to the ethics, data privacy, algorithmic bias, and institutional preparedness, which means that the emphasis on innovation should be combined with responsible application. The existence of powerful niche themes shows that specialized problems are actively studied, and the new ones like quantum education, blockchain credentials, and learning in the metaverse imply the emergence of new niches to be further investigated.

According to the international collaboration network, AI in education is a worldwide research focus, and there are a great number of alliances in North America, Europe, Asia and Australia. This can only be achieved through such collaboration to overcome common issues and the development of effective AI-based education solutions.

To conclude, the research advises educational institutions to invest in teacher education, come up with regulatory frameworks of safe AI integration, improve digital infrastructure, and encourage interdisciplinary research. In the long run, ethical application of AI can help establish more dynamic, accommodating and sustainable learning spaces-making AI the key to future intelligent education systems.

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