The Information Age for Education via Artificial Intelligence and Machine Learning: A Bibliometric and Systematic Literature Analysis

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Manuscript received October 25, 2023; revised November 27, 2023; accepted January 8, 2024; published May 20, 2024

***Abstract*—The integration of Artificial Intelligence (AI) and Machine Learning (ML) in education is a rapidly evolving field, yet the long-term implications and actual impacts on student learning outcomes require more in-depth study. Address this gap, our study offers a novel approach combining bibliometric analysis and a Systematic Literature Review (SLR), guided by the PRISMA methodology. The first phase, a comprehensive bibliometric analysis, identified key nations, educational institutions, journals, keywords, and influential authors in the realm of AI/ML in educational settings. This phase provided a macro-level understanding of the field's landscape, showcasing the global and interdisciplinary nature of AI/ML research in education. The subsequent phase involved a meticulous SLR of 22 select scholarly articles. This in-depth review sheds light on the current applications, emerging trends, challenges, and future directions of AI and ML in education. The findings from this dual-method approach offer a comprehensive roadmap for educators, researchers, and policymakers, underscoring the transformative potential of AI and ML in the educational sector. The review's extensive article collection provides a deep dive into the diverse and significant impact of AI in education, highlighting its role in areas such as predicting academic success, enhancing e-learning experiences, and preparing future generations for AI's integration in various fields like healthcare. This study not only underscores the revolutionary potential of AI in reshaping educational landscapes but also serves as a guiding framework for effectively deploying AI and ML technologies in education.**

***Keywords*—artificial intelligence, machine learning, education, Systematic Literature Review (SLR)**

I. Introduction

Artificial Intelligence (AI) and Machine Learning (ML) have emerged as breakthrough technologies in a variety of sectors, altering industry and our interactions with the world. Not only have these technologies acquired popularity, but they have also sparked a surge of innovation that has the potential to transform the landscape of education [1]. Educators, academics, and policymakers are studying the implementation of AI and ML into educational technology to use their potential for refining pedagogy, customizing learning experiences, and improving educational outcomes [2]. AI and ML integration into education has introduced new dimensions to teaching and learning. A significant use of AI is the development of Intelligent Tutoring Systems (ITS), which use AI algorithms to customize content and give tailored guidance, fostering more engagement and learning [3]. Moreover, the introduction of AI-powered data analytics tools has allowed educators to make educated choices based on data-driven insights [4]. In this rapidly developing field, patterns are beginning to emerge. For instance, Natural Language Processing (NLP) has become popular for automating procedures such as grading and delivering feedback, thereby lowering the burden on educators [5]. In addition, chatbots and virtual assistants powered by artificial intelligence are rapidly being incorporated into online education systems to give quick assistance, answer queries, and enhance the overall learning experience [1].

Integration of AI and ML into education is not devoid of barriers, despite its immense promise. Concerns regarding privacy have caused ethical issues [6] owing to the vast quantities of data involved. Moreover, the digital gap remains, raising questions about equitable access to AI-powered educational tools [7]. The future of AI and ML in educational technology seems to be bright. Ongoing research initiatives aim to refine algorithms, eliminate biases, and increase customization further [5]. Collaboration between technology developers and educators is required to ensure that AI-powered solutions are accessible to students from diverse backgrounds [8]. This paper's objective is to give a thorough and critical review of the influence of AI and ML on education. This study covers several scholarly articles, research studies, and academic contributions to determine the current trends, obstacles, and future directions of this dynamic field. The introduction of AI and ML into educational technologies has resulted in a surge of innovation. The goal of this systematic literature review is to provide educators, researchers, and policymakers with a road map for utilizing AI and ML to influence the future of education by harnessing AI and ML.

The novelty of this study lies in its unique combination of bibliometric analysis and Systematic Literature Review (SLR) using the PRISMA methodology [9]. This unique combination of bibliometric analysis and systematic literature review approach allows for a comprehensive exploration of the integration of AI and ML in education, identifying major contributors, trends, and future directions. The paper provides valuable insights for educators, researchers, and policymakers by highlighting the transformative potential of AI and ML in education. It stands out for its thorough

collection and analysis of articles, offering a broad understanding of AI's impact in education, and discussing future directions and ethical considerations. This comprehensive and forward-looking perspective makes the paper a novel contribution to the field of educational technology research.

To meet the goals of this study, this review will be divided into two key sections: a bibliometric analysis and a systematic literature review. These questions apply to the review's preliminary phase (the bibliometric analysis). The following questions are stated to address the objectives of this review:

1) What are the leading countries, educational institutions, journals, authors, and keywords associated with the integration of Artificial Intelligence and Machine Learning (AI/ML) in the field of education?
   Secondly, these questions are addressed to answer the Second Phase of the Review (SLR):
2) What AI and ML applications and impact related to the influence of AI on education?
3) What are the most important variables regarding AI and ML in education?
4) What are the most significant trends and findings concerning the influence of AI and ML in education?
5) What challenges are associated with the influence of AI and ML in education?
6) What are the future directions for AI and ML's impact on education?

II. Materials and Methods

A. Research Design

The objectives of this article will be achieved by the division of this study into two main components: a bibliometric analysis and a systematic literature review. These questions are preliminary in nature of the review (the bibliometric analysis).

A systematic methodology was used in our thematic study of the integration of AI and ML in education to identify recurring themes, trends, obstacles, and potential future directions in the domain. A thorough content analysis was conducted as part of the procedure to methodically ascertain and classify these components. Through an extensive examination of several scholarly articles, we successfully identified distinct obstacles pertaining to the integration of AI and ML in the field of education. These obstacles included technological constraints, ethical dilemmas, and obstacles in implementation.

The themes and trends were then classified according to their characteristics and recurrence rates. For example, the application of AI in personalized learning may have been a recurring subject, reflecting the move toward more individualized educational experiences. Ethical concerns, including but not limited to data protection and the proper use of AI technology in educational environments, were often emphasized as obstacles.

The findings derived from this theme analysis furnished us with a comprehensive comprehension of the challenges encountered within the domain of AI and ML in education. This comprehension is crucial for informing further research and implementation approaches, guaranteeing the efficacy and accountability of the development and integration of AI and ML technologies in educational environments.

B. Search Strategy

Using Scopus, a comprehensive search for peer-reviewed publications and conference papers on AI and ML in educational technology was done. The research was carried out on September 12, 2023. Following are descriptions of the search criteria we used. First, a bibliometric study was conducted; a preliminary search of the Scopus database produced 5,117 items. Using Scopus analysis, the researchers downloaded the dataset. Using the (Vosviewer) software, the mapping and occurrences between the results were shown. According to the findings of the study.

The VoSviewer software significantly contributed to the study of AI and ML integration in education by enabling the display of data, specifically in highlighting the leading nations that have made contributions to this domain. The utilization of this bibliometric instrument facilitated a precise and all-encompassing depiction of the intellectual terrain influenced by nations such as China, India, and the United States, as indicated by their considerable volumes of publications (1149, 636, and 417, respectively). The visualization capabilities of the VoSviewer assisted in clarifying the United States' leadership position, which it ascribed to its considerable financial resources and intensive research efforts. Additionally, the report highlighted the unique contributions of China and India, characterized by robust STEM education systems and substantial government funding.

In addition, the visualization capabilities of the software aided in emphasizing the distinctive contributions made by European countries, including the United Kingdom, Germany, Italy, and Spain. Each of these nations brought forth unique methodologies and practical technological applications for AI and ML in education, as well as inventive teaching strategies. In a similar vein, the noteworthy contributions of Canada, Australia, and Japan were further emphasized, since they each contributed distinctive talents and viewpoints to the subject matter.

In summary, the utilization of VoSviewer played a pivotal role in revealing a multifaceted and intricate approach to integrating AI and ML into the field of education. This suggests a prospective scenario in which pedagogical approaches are more individualized, efficacious, and all-encompassing, propelled by the revolutionary capacity of AI and ML technologies.

A list of keywords and Boolean operators, such as "artificial intelligence," "machine learning," and "educational technology," was utilized to extract important data from the recovered papers and provide more accurate results. As an example, TITLE-ABS-KEY (artificial intelligence, machine learning, education, and technology) For instance, AND (LIMIT-TO (EXACTKEYWORD, "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD, "Machine Learning") OR LIMIT-TO (EXACTKEYWORD, "Learning Systems") OR LIMIT-TO (EXACTKEYWORD, "Students") OR LIMIT-TO (EXACTKEYWORD, "Education" AND PUBYEAR > 2009 AND PUBYEAR 2023 AND" Last but not least, we restricted our search to social sciences, computer science, and arts and humanities (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "COMP") OR LIMIT-TO (SUBJAREA, "ARTS"). Moreover, only publications and

conference papers were included, such as AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp"). Example: AND (LIMIT-TO (LANGUAGE, 'English') AND (LIMIT-TO (SRCTYPE, 'p') OR (LIMIT-TO (SRCTYPE, 'j') AND (LIMIT-TO (PUBSTAGE, 'final')).

C. Data Synthesis and Analysis

The common themes, trends, challenges, and future directions regarding the influence of AI and ML on educational technology were discovered and investigated as follows:

- **Method**: Content analysis was employed to systematically identify and categories the common themes, trends, challenges, and future directions regarding the influence of AI and ML on educational technology.
- **Process:** Publications were reviewed to extract specific challenges related to AI and ML in education, such as implementation hurdles, ethical considerations, and technical limitations. These themes, trends, challenges, and future directions were categorized based on their nature and frequency of occurrence.
- **Outcome:** This analysis provided a clear understanding of the obstacles faced in the field and guided future research and implementation strategies.

D. Inclusion and Exclusion Criteria

To carry out this research, a predetermined set of inclusion and exclusion criteria was utilized.

In conducting our Systematic Literature Review (SLR), we implemented a meticulous approach to assess the quality and trustworthiness of the selected studies. Initially, our inclusion criteria were based on the publication years, specific keywords, language (English), and relevance to the subject area of AI and ML in education. From the initial pool, we successfully downloaded 30 papers for a more in-depth evaluation.

Our rigorous quality assessment criteria were pivotal in refining this selection. We scrutinized each study's design, emphasizing the clarity and appropriateness of research questions and hypotheses. The sample size of each study was evaluated for its adequacy and representativeness. Moreover, we closely examined the methodologies used for data gathering, ensuring their suitability for the research questions and their potential to yield unbiased and comprehensive results.

A critical aspect of our assessment was the validity and dependability of the results presented in these studies. We thoroughly evaluated how convincingly the data supported the study's conclusions, ensuring logical consistency and justifiable inferences.

This exhaustive process led us to a final selection of 22 high-quality publications. Each chosen study met our stringent criteria, ensuring that our SLR rests on a foundation of reliable and significant research. We have documented this selection process in detail, and an analysis of each included paper can be found in Supplementary. This approach has ensured that our literature review is not only comprehensive but also rests on the most trustworthy and relevant research in the field of AI and ML integration in education. The criteria are outlined in Table 1.

Table 1. The inclusion and exclusion criteria

Inclusion	Exclusion Criteria
Publications from the last 10 years (from 2013 to 2023) will be considered to capture recent developments in the field.	Non-peer-reviewed sources, such as blog posts and news articles, will be excluded.
Articles and publications written in English.	Studies that do not specifically pertain to AI and ML in educational technology will be excluded.
Research studies that primarily focus on the application and impact of AI and ML technologies in educational technology.	

E. Critical Appraisal and Discussion

To shed light on the current status of research on the subject, the synthesized data will be analyzed and argued critically. Examining major discoveries and their implications, as well as identifying any gaps in the available research,

F. Quality Assessment

Assess the trustworthiness of the chosen studies and ensure the quality of the assessment. After applying the inclusion and exclusion criteria, the range of years, the specific keywords, the language of the articles, and the subject area of the publications, only 219 papers were discovered. Then we tried to download these files, but only thirty were successfully downloaded. This SLR contains just 22 publications after analyzing studies based on criteria such as study design, sample size, data gathering methodologies, and validity and dependability of results. Supplementary illustrates the analyses of the papers included in this research.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework is a rigorous methodology designed to ensure transparent and comprehensive reporting in systematic reviews and meta-analyses. It is widely recognized for its structured approach to research and is particularly useful in evaluating randomized trials and other types of intervention research.

The PRISMA framework is fundamental to enhancing the quality and reliability of systematic reviews and meta-analyses. By adhering to its guidelines, researchers can ensure that their studies are conducted and reported with the highest level of rigor, thereby contributing valuable and trustworthy findings to the scientific community.

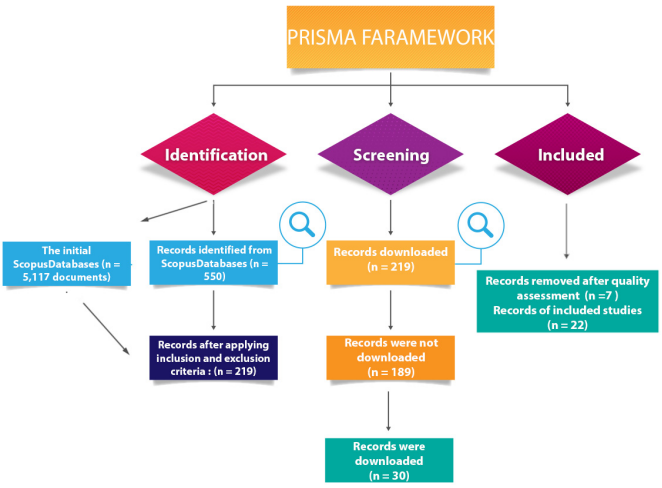

Fig. 1. PRISMA framework.

As shown in Fig. 1, the PRISMA framework was applied to depict the approach of this review.

III. Results

In order to get a comprehensive comprehension of our study subject, we have used a dual-method strategy that combines bibliometric analysis with a Systematic Literature Evaluation (SLR). By combining the comprehensive insights obtained by bibliometric analysis with the profound knowledge provided by the SLR, we are able to capitalize on this combination.

By smoothly shifting from the bibliometric analysis to the SLR, we guarantee the coherence of the storey. The bibliometric analysis is used to identify trends and patterns that provide a macro-level context for the discussion of the granular insights obtained from the SLR. By using this methodology, we not only bolster the logical consistency of our results but also get an all-encompassing comprehension of the field of inquiry.

In order to strengthen the interrelationship between the two approaches, cross-referencing is used throughout the work. The bibliometric analysis identifies significant advances and themes in the subject, while the SLR provides comprehensive analyses of chosen publications that dive into these issues. By using cross-referencing, it guarantees that the more general patterns detected by bibliometric data remain firmly grounded in the specific evidence presented in the literature review.

A. The First Phase (Bibliometric Analysis)

In the rapidly expanding area of Artificial Intelligence (AI) and Machine Learning (ML) in education, bibliometric analysis, a powerful method for evaluating the academic environment, has emerged as a crucial instrument. As educational technology continues to change and adapt conventional teaching methods, researchers and educators seek a deeper knowledge of the trends, key contributors, and information dissemination networks within this dynamic sector. By analyzing publications, citations, and patterns of cooperation, bibliometric analysis offers a systematic way for mapping the intellectual structure of AI and ML in education. In this introduction, we explore the relevance of bibliometric analysis in AI and ML in education for uncovering critical insights that will impact the future of education in a digitally driven world.

1) The top countries in the field of AI/ML integration with education

Bibliometric analysis offers a way for mapping the intellectual structure of AI and ML in education by examining publications, citations, and cooperation patterns. In this introduction, we go into the area of bibliometric analysis in AI and ML in education, exploring its relevance in uncovering critical insights that will impact the future of learning and teaching in a digitally driven world.

Moreover, to provide in-depth information in this analysis, the VOSviewer software was used to present the top countries in the field of AI and ML in education.

A bibliometric examination of the integration of AI and ML in education reveals that the United States, China, and India have a significant impact on the intellectual landscape, as shown by their respective considerable publication counts of 1149, 636, and 417. The leadership position in the subject may be attributed to the United States' substantial financing, intensive research endeavors, and a well-established ecosystem that fosters innovation in both education and technology. Due to strong government funding in AI, China's emphasis is distinguished by its rapid technical advancements and extensive practical implementations. Concurrently, the robust STEM education system and emerging technology startup ecosystem in India contribute substantially to its prominence in this field. Although European nations such as the United Kingdom, Germany, Italy, and Spain produce fewer articles, their contributions are distinct, including practical technological applications in Germany and novel teaching approaches in the United Kingdom. Significant contributions are also made by Canada, Australia, and Japan, each of which brings unique capabilities and viewpoints to the topic. The worldwide dispersion of research and innovation underscores a varied and complex strategy for incorporating AI and ML in the field of education. This bodes well for a future in which educational methodologies are more individualized, effective, and all-encompassing, propelled by the revolutionary capacity of AI and ML technologies.

Fig. 2. The top 10 countries leading the charge in publications showcase the global impact of AI and ML in education.

Fig. 3 illustrates the top 10 countries leading the charge in publications that showcase the global impact of AI and ML in education.

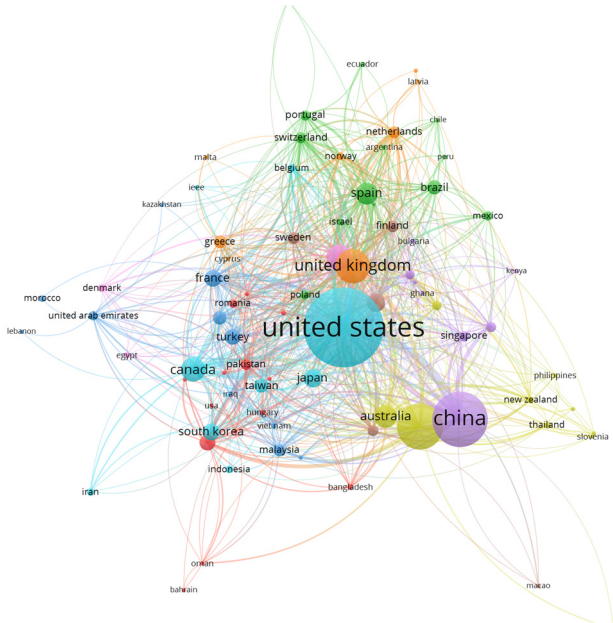

Fig. 3. Publications distributions by countries.

2) The top educational institutions in the field of AI/ML integration with education

By analyzing publications, citations, and patterns of cooperation, bibliometric analysis offers a systematic way for mapping the intellectual structure of AI and ML in education. In this introduction, we explore the relevance of bibliometric analysis in AI and ML in education for uncovering critical insights that will impact the future of education in a digitally driven world.

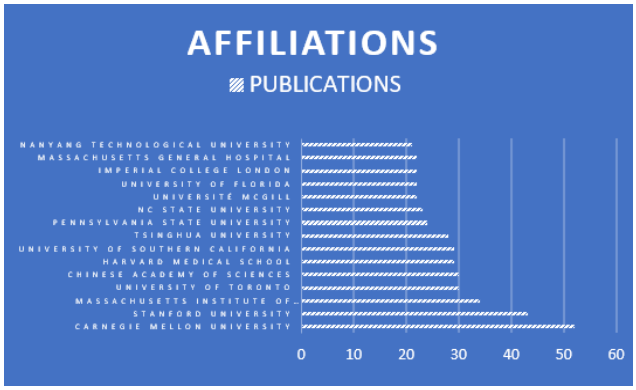

Fig. 4. Publications distributions by countries.

3) The top authors in the field of AI/ML integration with education

Table 2. The top authors in the field of AI/ML integration with education

Author	[1]TP	H-Index	[2]TC	Current affiliation	country
Breazeal, Cynthia L.	282	60	13,968	Massachusetts Institute of Technology, Cambridge	United States
Russell, Ingrid	52	11	319	University of Hartford, West Hartford	United States
Tedre, Matti	109	20	1,340	Itä-Suomen yliopisto, Kuopio,	Finland
Vartiainen, Henriikka	45	14	553	Itä-Suomen yliopisto, Kuopio	Finland
Markov, Zdravko I.	45	8	268	Central Connecticut State University, New Britain	United States
Becker, Brett A.	102	21	1,579	University College Dublin, Dublin	Ireland
Del Maestro, Rolando F.	188	53	7,942	Info Institut-Hôpital Neurologique de Montréal, Montreal	Canada
Koedinger, Kenneth R.	332	58	14,140	Carnegie Mellon University, Pittsburgh	United States
Ledwos, Nicole	19	10	443	Institut-Hôpital Neurologique de Montréal, Montreal	Canada
Mirchi, Nykan	16	9	447	Institut-Hôpital Neurologique de Montréal, Montreal	Canada

[1]TP= Total Publications, [2]TC= Total citations.

Table 2 lists the prominent writers about AI/ML integration with education. This paper analyses the first 10 noteworthy authors who have made substantial contributions to the burgeoning subject of AI and ML in education. Among these writers, Cynthia L. Breazeal stands out as a significant figure. Her impressive publishing career includes 282 papers, a stunning H-Index of 60, and 13,968 citations in total. Her affiliation with the Massachusetts Institute of Technology in Cambridge, Massachusetts, demonstrates her expertise in this sector. Table 2 lists the most prolific authors on the topic of AI/ML integration with education. This study analyses the first 10 notable authors who have made substantial contributions to the dynamic field of AI and ML in education. These famous writers are joined by a variety of additional key contributors from many countries and organizations, whose research and skills define the landscape of AI and ML in education.

4) The top journals that focus on AI/ML integration with education

Table 3. The top journals that focus on AI/ML integration with education.

Journal	[1]TP	[2]TC	Cite score	Time cited	Publisher
Lecture Notes in Computer Science	79,131	174,042	2.2	93	Springer nature
ACM International Conference Proceeding Series	49,408	37,118	1.1	43	Association for Computing Machinery (ACM)
Advances in Intelligent Systems and Computing	29,624	26,852	0.9	88	Springer Nature
Communications in Computer and Information Science	23,175	22,972	1.0	23	Springer Nature
IEEE Access	54,351	490,387	9	368	IEEE
CEUR Workshop Proceedings	20,633	23,405	1.1	14	CEUR-WS.org
Lecture Notes in Networks and Systems	25,876	18,888	0.7	72	Springer Nature
Journal of Physics: Conference Series	95,458	90,910	1.0	16	IOP Publishing
Proceedings of SPIE - The International Society for Optical Engineering	47,451	33,336	0.7	13	SPIE
Lecture Notes in Electrical Engineering	27,934	16,873	0.6	31	Springer Nature

[1]TP= Total Publications, [2]TC= Total citations.

Table 3 lists the leading journals concentrating on AI/ML integration in education. The 10 most prolific publications on the topic of AI and ML in education serve as key hubs for the dissemination of cutting-edge research and knowledge. Springer's "Lecture Notes in Computer Science" Nature has an incredible 79,131 Total Publications (TP) and 174,042 Total Citations (TC), with a strong Cite score of 2.2. With 93 citations, "A Corpus of Brazilian Legislative Documents for Named Entity Recognition," the "ACM International Conference Proceeding Series" of the Association for Computing Machinery (ACM) has 49,408 TP, 37,118 TC, and a Cite score of 1.1. The phrase has been cited 43 times. These papers, along with others on the list, are at the forefront of academic publishing in AI and ML in education, pushing the conversation and advancing our understanding of this dynamic topic.

5) The top keywords used in publication in the field of AI/ML integration with education

The graph displays the most often used phrases in the area of AI/ML integration with education. A comprehensive assessment of the most significant keywords in the field of AI and ML in education reveals the phrases that have the greatest impact on this dynamic industry. With a staggering 3,869 occurrences and a substantial total link strength of 38,691,

"artificial intelligence" emerges as the dominant subject among these terms, illustrating its immense significance in the discussion. With 2,442 instances and a total link strength of 26,221, "machine learning" closely follows, emphasizing its immense influence at the intersection of AI and education. Other important keywords such as "learning systems," "education," and "learning algorithms" play a substantial role in the creation of the narrative, which represents the intricacy of AI and ML in education research. This research illustrates not just the frequency of these phrases but also their cumulative impact on the development of this burgeoning field of study.

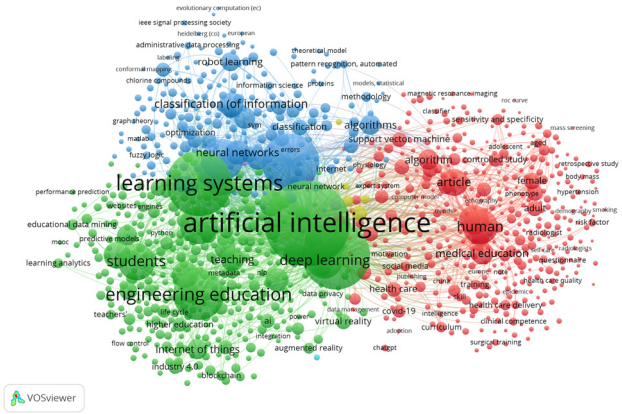

Fig. 5. The most used keywords used in publication in the field of AI/ML integration with education.

B. The Second Phase (the Systematic Literature Review, SLR)

The broad literature review uncovered significant new insights about the use of Artificial Intelligence (AI) and Machine Learning (ML) in educational technology. These fresh understandings emphasized common themes, noteworthy findings, emerging trends, acknowledged challenges, and prospects.

1) AI and ML applications related to AI's impact on education

This section emphasized AI and ML applications related to AI's impact on education based on the reviewed research. The most important AI and ML applications related to the impact of AI on education are shown in Table 4.

Table 4. AI and ML Applications Related to AI's Impact on Education.

Studies	AI and ML Application	AI's Impact on Educational Technology
[10]	Education System Data and Feedforward Spike Neural Network	This paper discusses processing education system data using a feedforward spike neural network. Feedforward networks are utilized for many jobs, and neural networks may learn patterns from input.
[11]	Machine Learning, Learning Analytics, Data Mining, and ALTS	This research examines machine learning, learning analytics, data mining, and adaptive learning technology systems (ALTS) in education. These methods use data and algorithms to enhance learning and adapt material.
[12]	Artificial Intelligence-Based Educational Techniques	Machine learning, learning analytics, data mining, and adaptive learning technology systems (ALTS) in education are examined in this research. Data and algorithms are used to enhance learning and tailor material.
[13]	Machine Learning Algorithms	It examines how machine learning, learning analytics, data mining, and adaptive learning technology systems (ALTS) affect education. These methods boost learning and modify material using data and algorithms.
[14]	Social Network Analysis	A social network's linkages and interactions are studied in social network analysis. This may help educators understand student collaboration and communication.
[15]	AI and ML References	These papers highlight the importance of AI and ML in education.
[16]	Multiagent System and Machine Learning Algorithms	This paper addresses multiagent systems, which feature several agents working together to accomplish objectives. Multiagent systems may use machine learning techniques like Decision Tree (DT), Logistic Regression (LR), Random Forest (RF), Naive Bayes (NB), and K-nearest neighbors (KNN) to address educational challenges.
[17]	Intelligent Virtual Educational System	This paper proposes an intelligent virtual educational system that leverages AI to improve learning.
[18]	Deep Learning and Augmented Reality	Machine learning using multilayered neural networks is called deep learning. AR can improve education by overlaying digital information on the actual environment.
[20]	AI in Education and Virtual Environments	Neural networks with several layers are used in deep learning. AR overlays digital information on the actual environment to improve education.
[21]	Generative Adversarial Network (GAN) and Machine Learning Algorithms	Multiple-layer neural networks are used in deep learning. AR adds digital information to the actual world, improving education.
[22]	AI and ML References	These papers highlight the importance of AI and ML in education. AI and ML can automate administrative duties, customize learning, and evaluate educational data for insights.
[23]	AI Systems	This study underscores the presence and relevance of artificial intelligence (AI) systems in the context of education.
[24]	Machine Learning Algorithms	This research highlights the educational potential of ML algorithms like Naive Bayes, Decision Tree, Random Forest, and Neural Networks.
[25]	Intelligent Tutoring Systems	This study underscores the Intelligent tutoring systems aim to provide personalized instruction to students. Tracing and tutoring using a decision tree is mentioned in this context.
[26]	Intelligent Multilevel Item Bank (I-MIB) Model	This research presents the Intelligent Multilevel Item Bank (I-MIB) Model, which may be used to manage and provide instructional material.
[27]	Intelligent Decision Support Systems	This research proposes an Intelligent Multilevel Item Bank (I-MIB) Model for educational material management and delivery.
[28]	AI and Data Analysis of LMS	This research shows how AI and data analysis are employed in online education platforms, Learning Management Systems (LMS). Content recommendations and student-specific evaluations offer individualized learning. Use predictive analytics to identify at-risk pupils for prompt treatment.
[29]	5G Model	This paper describes the 5G concept, which includes Enhanced Mobile Broadband, Massive Machine Type Communication, and Ultra Reliable and Low Latency Communication. 5G may affect educational material delivery and accessibility.
[30]	Supervised and Semi-Supervised Machine Learning	The 5G model includes Enhanced Mobile Broadband, Massive Machine Type Communication, and Ultra Reliable and Low Latency Communication, according to this report. 5G may affect educational material delivery and accessibility.

Table 4 outlines the 5G concept, which consists of three key components: enhanced mobile broadband, massive machine-type communication, and ultra-reliable and low-latency communication. The distribution and accessibility of educational information might be affected by 5G technology.

2) Variables associated with AI and ML in education

The outcomes of this research together demonstrate the many educational applications of artificial intelligence, machine learning, and data analysis. These apps consist of tailored instruction, administrative assistance, and data-driven decision-making.

Table 5. Variables associated with AI and ML in education.

Studies	AI and ML variables	AI and ML impact
[10]	Predicting the Academic Performances	Using AI to predict students' academic success based on past data and performance metrics is certainly involved.
[11]	Deep Learning and Automated Responses	This most likely entails using AI to predict the academic successes of pupils based on past data and performance markers.
[12, 13]	Students' Skills and Academic Forecasting	These references may belong to AI-powered tests and data analysis for forecasting the talents and academic development of pupils.
[14]	Student Performance in Higher Education Online Courses	AI might be used to assess and enhance the performance of students enrolled in online courses for higher education.
[15]	Students' Perceptions of AI	how students perceive and engage with artificial intelligence technology in educational environments.
[16]	Enhancing E-Learning	AI is expected to be used to improve the e-learning experience by customizing and adjusting information to each student.
[17]	Efficiency Improvement in Primary Education	AI may be used to improve the efficacy and efficiency of basic education operations.
[18, 19]	LAB Training and Student Perceptions	AI may be included into laboratory teaching, and student perspectives and experiences with this technology are likely being investigated.
[20]	Personalized Learning Systems	Individualized learning systems powered by artificial intelligence are meant to customize educational material and experiences for each learner.
[21]	Augmented Tutoring in Higher Education	In higher education, AI-augmented tutoring may entail the use of intelligent tutoring technologies to assist students.
[22]	Alignment of Education Platforms with Learners' Needs	AI will likely be utilized to better match educational platforms and apps with the tastes and expertise of students, ultimately enhancing the educational experience.
[23]	Online Exam Supervision Technologies	This might entail the use of AI-based technology to monitor and supervise online examinations in order to avoid cheating.
[24]	Prediction of Student Outcomes	It is possible to use AI to forecast students' grades and performance, as well as to discover early indicators of school failure or dropout.
[25]	Improving Students' Learning Outcomes	Through individualized interventions and material suggestions, AI is expected to be used to improve and optimize students' overall learning results.
[26]	Evaluation of Undergraduates	AI may be used to examine and evaluate undergraduate students' performance and growth.
[27]	Ubiquitous Learning Environments	This is anticipated to include the development of everywhere-accessible learning environments enabled by AI-driven technology.
[28]	Improving Learning Outcomes	This is expected to include the development of everywhere-accessible learning environments, enabled by technology powered by artificial intelligence.
[29]	Beneficiaries of 5G Technologies in Education	This might include investigating how educational users can benefit from 5G technology's high-speed and low-latency capabilities.
[30]	STEAM Students' AI-Thinking Skills	This reference may examine how AI is incorporated into the curriculum of Science, Technology, Engineering, Arts, and Mathematics (STEAM) pupils to develop critical thinking and problem solving.
[31]	Teaching and Learning in Higher Education	The significance of AI in revolutionizing teaching and learning processes in higher education institutions is likely the focus of this article.

Each of these examples highlights a unique element of how AI is transforming and enhancing several parts of the educational environment, including customized learning, assessment, and operational efficiency.

3) Trends and findings in AI and ML integration with education

Based on our analysis, these articles give a comprehensive overview of how Artificial Intelligence (AI) is reshaping the educational environment by highlighting the most significant trends and discoveries in the integration of AI and ML with education. In this collection, we investigate a variety of facets of AI's impact on the education sector. In Liu's study [10], a robust neural network model is used to predict student grades using grade and course data. The transformational potential of AI is illustrated in [11], which revolutionizes school management and enhances the educational experiences of students. This chapter examines the emergence of distinct student groups with comparable traits as a result of AI-driven approaches. This chapter covers the use of machine learning to predict learning patterns and support challenging students. In the context of online education, the sentence [14] highlights the precision of prediction models. The section [15] emphasizes the significance of artificial intelligence in defining the future of medicine and the necessity for training opportunities in this dynamic field. The study [16] proposes a unique multiagent e-learning system designed to investigate educational environment interactions. The line [17] emphasizes the advantages of intelligent virtual educational systems. The article [18] provides a comprehensive description of the combination of augmented reality and object recognition that results in immersive educational experiences.

Moreover, Rocsana [19] indicates that instructors are willing to incorporate AI in higher education. The passage demonstrates how Artificial Intelligence in Education (AIEd) technology supports personalized learning paths, thereby enhancing student engagement and expediting the learning process [20]. The need for emotionally intelligent AI systems that can adjust to the pace, time, and emotional demands of individual students is highlighted. The article [22] examines how AI and machine learning contribute to improved learning outcomes, talent identification, and collaborative learning. Institutions considering the use of online proctoring technologies will find assistance in [23, 24] demonstrates the amazing accuracy of AI in predicting student grades. The section [25] discusses the development of educational tutors that may be deployed by anyone with no programming

experience. Reference assesses the effectiveness of an I-MIB undergraduate evaluation methodology. The text [27] emphasizes the heterogeneity in machine learning research, including sample size and technique selection variances. The section [28] addresses the advantages of granular data analysis for the advancement of online education, including the optimization of learning materials and activities. The section [29] forecasts that 5G and the Internet of Things (IoT) will transform education. As explained in [30], AI promotes the development of AI literacy and critical thinking abilities in STEAM students. Finally, Popenici [31] anticipates that AI-powered software will eventually replace conventional teaching methods in higher education, emphasizing the significance of ethical issues and knowledge preservation. These papers give a comprehensive evaluation of the significant impact AI will have on the educational environment when examined as a whole.

4) Challenges in AI and ML adoption

The outcomes of these studies give a comprehensive understanding of the implications that Artificial Intelligence (AI) will have on the educational system. While most students face obstacles in their individual educational environments, for instance, Liu [10] highlights the challenges connected with data availability and interpretability in prediction tasks. According to Singh [11], new possibilities and limitations in higher education are modifying institutional governance and design. The objective of Xu's research [12] is to satisfy diverse educational needs by examining the use of algorithms in both conventional classrooms and e-learning situations. The sentence [13] acknowledges the benefits of machine learning in predicting academic occurrences as well as its limitations, such as mistake risks and data complexity. The section [14] discusses the progress of education as a result of technological advances, which have reduced the need for physical campuses. The text underlines the need for AI education in formal curricula, particularly considering AI's rising clinical use. Hessen [16] highlights the need for measuring teachers' digital abilities for successful digital problem-solving in education. In Estrada's study [18], the potential of higher education institutions to drive digital innovation and adapt to emerging technologies is examined.

For instance, [10] demonstrates the availability and interpretability of data in prediction tasks. New possibilities and restrictions in higher education are reshaping institutional governance and design, discusses the use of algorithms in conventional classrooms and e-learning to satisfy a range of educational needs [11, 12]. In addition to recognizing the advantages of machine learning in forecasting academic events, Onyema [13] also acknowledges its limitations, including mistake risks and data complexities. Jokhan [14] underscores the transformation of education as a result of digital advances, which has the potential to lessen reliance on physical campuses. Considering AI's burgeoning therapeutic applications, Pucchio [15] highlights the necessity for AI teaching in formal curricula. Hessen [16] emphasizes the need for measuring teachers' digital abilities for effective digital problem-solving in education. Moreover, Vidal [17] stresses the immersive potential of Augmented Reality (AR) but highlights problems with multitasking recognition, arguing for the incorporation of deep learning algorithms. This section discusses the opportunities for institutions of higher education to drive digital innovation and adapt to advancing technologies.

5) Future directions and recommendations

Collectively, these studies provide light on the possible future directions and effects of Artificial Intelligence (AI) in education and give insight into those future possibilities.

The importance of timely intervention by teachers and the role of AI in modifying student learning are addressed in [10]. As stated in research [11], the use of AI to predict students' talents promotes proactive educational preparation. This chapter studies the use of Natural Language Processing (NLP) to improve learning systems and adapt to evolving educational contexts. In previous study, the use of machine learning to enhance academic forecasts and decision-making is stressed [13]. In the digital era, virtual education will have a significant influence, necessitating an adaptive and global curriculum. In view of the expanding use of AI technology in therapeutic procedures, Pucchio [15] emphasizes the need to educate the future generation. Clause [17] emphasizes the need to measure teachers' digital abilities to provide a high-quality education that tackles digital challenges. Estrada [18] provides an innovative teaching technology that integrates augmented reality, artificial intelligence, and remote learning to enhance the study of electrical circuits. For future advantages, Rocsana [19] promotes the use of clear concepts and efficient technology in educational institutions. According to Olga's research [20], AI-powered solutions designed for a specific institution may have broader applications. AI is used by [21] to anticipate the future of higher education, taking into consideration challenges and shifting government regulations. encourages future research on AI and ML systems for higher education, especially in low- and middle-income countries. Coghlan [23] study on the implications of Online Proctoring (OP) technology on stakeholders and ethical issues Expanding algorithm parameterization and incorporating demographic data are provided for future research in [24]. Using apprentice learning paradigms, Maclellan [25] explores teacher development and presents a unique structure for producing instructors of experimental design. The section [26] discusses the use of data mining to evaluate student performance and improve curriculum quality. In future research, Caitlin [27] proposes AI-based solutions for a variety of e-learning platforms and technologies. William [28] proposes integrating blockchain technology with the Internet of Things (IoT) to improve data security and instructional models. With the arrival of 5G networks, Dake [29] investigates the possible advances to teaching and learning processes that may occur. Using simulations, how [30] explores potential AI-thinking instruction situations for STEAM instructors. Lastly, [31] highlights the significance of doing an ethical study on AI development limitations and the possible monopolization of human knowledge and perspectives.

Collectively, these studies shed light on the always shifting environment of Artificial Intelligence (AI) in educational settings, as well as on the possible future orientations and repercussions of Artificial Intelligence (AI) in education and give insights into those potential future courses.

IV. Discussion

In the first part of the study, the research on AI and ML in education gives unique worldwide insights into this quickly growing topic to address the first research question. The top contributors, headed by the United States with 1,149 articles and followed by China and India with 636 and 417 papers, respectively, reflect a worldwide commitment to expanding educational technology expertise. Carnegie Mellon University, Stanford University, and MIT are at the forefront of AI and ML in education, demonstrating their global span. Reputable writers, such as Cynthia L. Breazeal, with 282 publications, have a substantial impact on the area. Keywords such as "artificial intelligence" and "machine learning" emphasize the significance of these technologies. This exemplifies the collaborative character of AI and ML in education, which transcends national boundaries to promote the globalization of educational technology.

In the second phase, the systematic literature study shows AI and ML applications in education, including customized learning, prediction models, and administrative automation, to answer the second research question. These technologies, including adaptive learning and virtual educational systems, facilitate individualized learning. The scope of AI includes social networking, machine learning, and Generative Adversarial Network (GANs) for dataset analysis. The use of ML methods such as Naive Bayes and Decision Trees demonstrates their adaptability. These studies highlight how AI and ML may transform education via tailored content, evaluation systems, and pervasive learning environments. The 5G paradigm is anticipated to improve the distribution and accessibility of educational information.

The third study topic investigates AI and ML integration trends and results. AI improves school management and promotes tailored teaching, while sophisticated neural network models predict academic performance. Machine learning is used to predict learning patterns and aid students with learning difficulties. Virtual education, augmented reality, and AI systems with emotional intelligence revolutionize learning experiences. There is discussion about online proctoring, AI's capacity to anticipate student grades, and AI-powered tailored material. These patterns demonstrate the influence of AI on academic attainment and administrative effectiveness.

In its fourth research topic, the study analyses obstacles to the adoption of AI and ML. The importance of openness and accountability is emphasized in relation to data availability, governance, and ethics. The potential of AI to forecast student grades and enhance assessment methods is highlighted. The research predicts the revolutionary importance of 5G networks in education, AI literacy for STEAM students, and ethical implications for AI development.

The concluding research question provides future directions and suggestions. AI is seen as a tool for customizing student learning, predicting talent, and preparing healthcare operations for AI integration. AI's potential inside enterprises is emphasized by emphasizing clear concepts and technological implementation. The future of higher education will require responding to problems, advancing AI research, and delivering AI solutions for a variety of learning platforms. It is anticipated that blockchain, IoT, and 5G networks would improve education. Ethical issues are critical, underlining the necessity for AI development restrictions and diverse points of view.

These exhaustive results highlight the revolutionary potential of AI and ML in education, as well as the obstacles and ethical issues that institutions must face while embarking on this educational path.

A. Interdisciplinary Collaboration: Key to Maximizing AI and ML Benefits in Education

Improving AI/ML in Education via Collaboration: Complexity be damned, the integration of AI and ML in education necessitates a diverse strategy. It is crucial that educators, technologists, and politicians work together to guarantee the ethical and successful use of these technologies. Educators provide educational experience and discern actual classroom requirements, whilst technologists add technological proficiency and inventive resolutions. The establishment of supporting frameworks and the prioritisation of ethical issues in technological integration may be facilitated with the assistance of policymakers.

Addressing the Divide between Theory and Practice: The implementation of theoretical AI/ML developments in educational environments might be facilitated by collaborative endeavours. The input of educators about the practicality of these technologies is crucial for ensuring that they satisfy the practical requirements of both students and instructors. Technologists have the ability to modify AI/ML solutions in response to feedback from those directly involved in education, therefore enhancing the usability and efficacy of educational technologies.

Aspects of Privacy and Ethics: Ethical and privacy concerns are of the utmost importance when it comes to the use of AI and ML in education. By adopting a collaborative approach, it is possible to create and apply new technologies while maintaining a comprehensive awareness of the ethical ramifications and privacy requirements that are unique to educational settings. The involvement of legal professionals, ethicists, and educational stakeholders is crucial for addressing these complex issues.

Promoting a Culture of Innovation and Inclusivity: Educational establishments may cultivate an environment that encourages innovative thinking and appreciates varied viewpoints by encouraging multidisciplinary cooperation. Ensuring inclusion is of the utmost importance in the development of AI/ML solutions that are accessible and equitable for students of all backgrounds. Additionally, collaborative efforts may result in more novel ideas, because diverse perspectives often inspire innovation and pave the way for breakthroughs.

Capacity Building and Professional Development: Professional development is essential for educators to properly incorporate AI and ML into their lessons. By collaborating with technologists, educators may get the expertise and tools required to comprehend and implement these technologies. This capacity-building initiative guarantees that educators not only use AI/ML technologies but also actively participate in their advancement and improvement.

Future Directions and Research: The potential for more extensive studies on the effects of AI and ML in education exists when educators and technologists engage in

collaborative research. Further investigations across disciplines may provide more profound understandings of the efficacy of these technologies, therefore informing further advancements and guaranteeing their congruence with educational objectives and benchmarks.

B. Practical Implications for AI and ML Application in Education

The previous sections' ideas have various educational applications. For instance, Liu and Gerlache [10, 24] shows that academic performance and student outcome prediction have practical implications for educators and institutions. AI and machine learning algorithms help schools identify at-risk pupils and respond quickly, improving student achievement.

Personalized learning systems [20] suggest that schools should invest in AI-driven technology that customizes teaching for each student. Individualization boosts interest and learning speed.

Teacher Training: Assessing teachers' digital skills is vital in the digital era [17]. Institutions should prepare teachers to overcome digital challenges and use AI-driven instructional technology. Augmented reality with AI in education [18] provides a new learning experience. Higher education institutions could develop similar methods to engage students and increase their understanding of difficult topics. Ethics and data privacy must be addressed as AI becomes more prevalent in education [19]. To safeguard student data and encourage AI usage, schools should establish explicit guidelines. Curriculum Change: AI is becoming more important in many fields, including medicine [15], so the official curriculum must include AI education. Schools should provide AI courses and modules to educate students about AI-integrated workplaces. As online proctoring technology advances [22], colleges must consider ethical and privacy issues. Administration and transparency are crucial to balancing security and student rights. 5G Integration: Education institutions should plan for increased content delivery and accessibility when 5G networks arrive [29]. They should explore how high-speed, low-latency networks might provide new teaching experiences. The rise of AI-thinking abilities among STEAM students [30] highlights the need to teach AI literacy. Students should be given AI-related critical thinking and problem-solving tools and training.

Future AI and ML education system research [22, 31] emphasizes innovation. Educational institutions must collaborate on research and use new technologies to stay ahead of the curve. Embracing these practical effects may help educational institutions embrace AI's transformative capability while addressing its ethical issues. This proactive approach guarantees that AI in education helps instructors and students.

C. The Benefits of Artificial Intelligence and Machine Learning in Age Education

The integration of Artificial Intelligence (AI) and Machine Learning (ML) into education brings a multitude of benefits, fundamentally transforming the educational landscape. These technologies enable personalized learning experiences, adapting to individual students' styles and needs, thereby enhancing learning efficiency. AI and ML facilitate the automation of routine tasks, such as grading, allowing educators to focus more on teaching and student interaction. They also enhance accessibility, particularly for students with disabilities, through tools like speech recognition and text-to-speech. Data-driven insights gained from AI and ML help in identifying learning gaps and tailoring teaching methods. Interactive learning environments, fostered by AI-powered educational games and simulations, make learning more engaging. Moreover, these technologies offer global education opportunities, breaking down geographical barriers and enabling access to quality education worldwide. They support continuous learning and professional development across various life stages. The scalability of AI and ML solutions ensures consistent educational experiences for a large number of students. Educators benefit from AI assistance in curriculum development and teaching strategies, guided by data analytics. Importantly, integrating AI and ML in education prepares students for a future where these technologies are increasingly prevalent across industries. However, this integration must be approached with careful consideration of ethical issues, data privacy, and the need for human oversight, ensuring a balanced and responsible use of AI and ML in educational settings.

D. The Recent Integration of ChatGPT and Large Language Models

The recent integration of ChatGPT and Large Language Models (LLMs) into education marks a significant advancement, offering various benefits. These models enable personalized learning, tailoring assistance to individual students' needs and learning styles, thus accommodating diverse learning speeds and preferences. They also supplement curricular content, aiding educators in creating interactive materials and providing updated information on numerous subjects. Particularly in language education, LLMs offer invaluable assistance in enhancing reading, writing, and conversational skills across multiple languages. Students can leverage these models for research and writing support, while educators can use them to develop lesson plans, quizzes, and educational games, enriching the classroom experience. Additionally, LLMs foster interactive learning environments, making education more engaging and accessible, especially for those with disabilities or learning difficulties. Importantly, their use in educational settings encourages the development of critical thinking and digital literacy skills, teaching students to discern the quality of AI-provided information. For educators, these models offer continuous professional development opportunities, keeping them abreast of the latest in their fields. However, the implementation of these technologies in education must be approached with a focus on ethical considerations, data privacy, and the importance of human oversight, ensuring these tools complement rather than replace human educators. This balanced approach is crucial for their successful integration into the educational landscape.

E. Strategies for Integrating AI and ML in Education: Enhancing Learning and Teacher Support

Educational institutions can enhance learning and information access for students while aiding teachers in integrating AI and ML technologies through several key strategies. First, incorporating AI into the curriculum helps students understand and apply these technologies. Providing professional development for teachers is crucial for them to

effectively use AI in teaching. AI can also create personalized learning environments and assist in student assessment, offering adaptive resources and feedback. To address the challenge of AI-generated student work, institutions should invest in tools capable of detecting such content, emphasizing the importance of academic integrity. Additionally, fostering critical thinking skills, promoting digital literacy, and collaborating with AI and tech companies are essential steps. These measures not only facilitate the integration of AI and ML in education but also ensure educators are equipped to navigate and leverage these advancements effectively.

F. Ethical Considerations Associated with the Integration of AI/ML in Education

This segment delves into the ethical implications linked to the incorporation of AI and ML in the field of education, with an emphasis on pivotal concerns such data privacy, security, and the possibility of AI algorithmic biases. It is acknowledged that these considerations are fundamental to the ethical integration of AI technology into educational environments.

Ensuring the security of student data is of the utmost importance to us. The collection and analysis of extensive student data is a common aspect of AI use in education, which raises serious privacy and data security concerns. We emphasize the criticality of establishing comprehensive data protection protocols and complying with stringent data privacy laws to ensure the security of student information.

We also investigate the security implications of AI systems in educational environments, which is an additional critical aspect. This consists of safeguarding data from breaches and illegal access. The significance of adopting sophisticated security mechanisms and consistently monitoring AI systems for vulnerabilities is emphasized in our study.

We investigate the possibility that AI algorithms include intrinsic biases, which is a substantial ethical problem. Prevalent bias in algorithms may result in inequitable or prejudiced instructional methodologies. Our research underlines the need of establishing responsible and transparent AI systems, and we urge for the use of varied datasets in the training of AI models to reduce biases.

We conducted a comprehensive assessment to verify the validity and reliability of the findings in this research, ensuring that any conclusions drawn were logically consistent and supported by evidence. As a result, we were able to identify 22 articles of exceptional quality that satisfied our rigorous standards, so guaranteeing that our Systematic Literature Review (SLR) is founded upon dependable and substantial research. The selection process has been well documented, and an analysis of every selected work may be found in Supplementary. By using this methodology, we ensure that our literature evaluation is not only thorough but also based on the most reliable and relevant studies about the integration of AI and ML in education.

V. Conclusions

In conclusion, we provide an all-encompassing synopsis of forthcoming trends and practical suggestions for policymakers, academics, and educators concerned with the successful use of AI and ML technologies in the field of education. Modern methods, which are grounded in our research outcomes, seek to direct the discipline towards the creative and responsible use of these technologies.

- **For educators:** We propose that they prioritize the incorporation of AI technologies in a manner that harmonizes with conventional pedagogical approaches. It is imperative that educators undergo training to acquire the necessary skills and knowledge to effectively use AI technology. This will empower them to customize learning experiences for students, hence enhancing their engagement and overall academic performance.

Ongoing investigation into ethical concerns, such as data privacy and prejudice in AI systems, is of the utmost importance for researchers. To reduce biases, researchers should strive to design AI systems that are more responsible and transparent and contribute to the compilation of varied datasets. Additionally, artificial intelligence-powered educational solutions may result from interdisciplinary research collaborations.

- **Regarding Policymakers:** It is critical that policies promoting the secure and equitable implementation of AI in education be established. It is the responsibility of policymakers to support financing for AI research and deployment in educational settings, maintain data privacy and security, and encourage fair access to AI educational technologies via the development of rules.
- **Practical Strategies:** Investing in teacher training for AI technologies, establishing AI ethics guidelines for educational settings, and encouraging partnerships between academic institutions and technology companies to facilitate the exchange of resources and expertise are practical strategies supported by our findings.

By directing attention towards these prospective trajectories and executing these practical suggestions, we may steer the responsible and efficient use of AI and ML technologies within the realm of education. By adopting this methodology, it guarantees that the capabilities of AI and ML are used to optimize educational experiences, all the while tackling ethical, practical, and technological obstacles.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

H.A. Conducted the analysis, wrote the paper, and led the project; F.A.; verified the data; M.A.B.M.A. finalized the first draft; M.D. finalized the first draft; A.S.B.A. finalized the first draft; all authors had approved the final version.

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