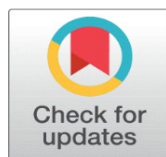


A BIBLIOMETRIC REVIEW OF ROLE OF ARTIFICIAL INTELLIGENCE IN EDUCATION

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ABSTRACT

Artificial Intelligence possesses the capacity to fundamentally transform education by rendering it more tailored, inclusive, and effective. Nevertheless, it is imperative to confront challenges such as ethical dilemmas, data confidentiality, and the disparity in digital access to ensure sustainable integration. Prospective developments in Artificial Intelligence ought to emphasize equity, accessibility, and collaborative efforts to optimize its influence on educational outcomes. Furthermore, the National Education Policy 2020 (NEP 2020) represents a significant advancement towards the reformation of the Indian educational framework. The objective of the policy is to foster education that is more just, inclusive, and comprehensive. Technological innovations serve as a catalyst in facilitating sustainable progress within the educational domain. This will enhance students' competencies and prepare them for industry demands. The NEP acts as a strategic framework to realize innovation, creativity, and excellence. Additionally, the NEP has recognized the effective application of Artificial Intelligence (AI) in both pedagogical and learning processes. By using bibliometric analysis, this research provides a comprehensive overview of the applications of artificial intelligence within higher education. Web of Science and Scopus databases have been used to find out annual scientific production, prolific journals, cite scores, and trends in education.

Keywords: Artificial Intelligence, AI And Education, Intelligent Tutoring Systems, Machine Learning

1. INTRODUCTION

Artificial intelligence (AI) technology has existed in some form since the middle of the 20th century. We now know that artificial intelligence (AI) has a significant impact on almost every field, including education. AI is now being used for its applications and it is very easy to access. AI has shown a revolution in learning and teaching methods. Educators can use different AI-based tools to give personalised experiences to their students. This will facilitate the student's personalised learning experience, which results in better outcomes. Knowledge is more accessible and affordable. We should thank AI that students can now study from anywhere and anytime (S. V. Singh & Hiran, 2022). Data is a kind of 'New Oil' and AI depends on an enormous amount of data (Palmer, 2006). The learning role of AI in education has now become AI literacy, received a lot of attention these days, and has become a sensational topic for the policymakers of the country (Miao et al., 2021).

Artificial intelligence has the potential to address several issues that are faced by the education system and it brings innovation in learning and teaching. Thus, SDG4 will be on a fast track. UNESCO also stated that it will support its member

states in the employment of AI technologies for the accomplishment of the Education 2030 agenda. It played the role of a game changer during the Covid period. Massive open online courses (MOOCs) have become very popular and a reality. The number of students who are using MOOCs are growing rapidly. Artificial intelligence provided many applications that were used massively by educators to develop content during the time. ChatGPT created a buzz in 2022 among students. Artificial intelligence (AI) is transforming our education system into a deep learning system. It has started a new era of education (Malik et al., 2019). Interactive charts, graphs, dashboards, quiz, and even gaming patterns are used to solve subject-related problems. Teaching with AI includes learning through virtual simulated agents that use the human-centric strategies of teaching. Artificial intelligence (AI) has the potential to revolutionize the way we teach and learn, making education more efficient, personalized, and engaging. By integrating AI technologies such as natural language processing and machine learning into the educational process, we can significantly enhance learning experiences. AI-driven algorithms enable educators to customize instruction for each student by analyzing data, identifying patterns, and making informed predictions, thereby tailoring learning to individual needs. This research try to fill this research gap involves analyzing patterns, trends, and the distribution of research across various dimensions (e.g., topics, journals, geographic distribution, trends) to highlight underexplored areas in the existing literature.

2. REVIEW OF LITERATURE

AI has the potential to revolutionize education by enhancing teaching and learning experiences, improving assessment accuracy and efficiency, and generating personalized feedback for students (Owan et al., 2023) and skill levels and learning abilities (Avery, 2017). It has a significant influence on the education system, and it is widely applied in both centralized and decentralized educational institutions (Madathil et. al, 2023) also provides, provide personalized feedback, and adapt teaching strategies to meet the unique needs of students (Owan et al., 2023). The trust of educators in technology plays a crucial role in the adoption of education technology. The trust depends on cognitive, accessible evidence and algorithm transparency, emotional responses, and explainability (Kizilcec, 2023). The technological landscape is changing rapidly which need to plan our education system. There is a need to design a typology of AIED (AI in education and learning) system which describes the various ways that how can we use AI in education and learning. These changes should bring development in education also (Holmes & Tuomi, 2022).

The demand for online education has also increased which has led to the creation of new technology. AI teaching assistant is the creation of such demand. In United States, AI assistants have been implemented in some courses. They found that students are perceiving AI assistants very useful and easy to communicate (Owan et al., 2023) This system gives access to the students to retrieve necessary documents and information and also facilitates interaction between teacher and students (Barella et al., 2009).The AI adoption among university teachers depends upon the attitude and perceived usefulness of AI technology. AI technology can be used to increase the student's learning effectiveness. Now, teachers are ICT trained, when teachers think about the integration of AI with their teaching, they measure the usefulness of the technology and after the evaluation, they adopt it and start using the technology in teaching methods (Y. Wang et al., 2021).

On the other side, AI should not and will not replace the teacher in the classroom. The reason is humanity. The teachers have unique characteristics and human expertise. AI cannot represent a human teacher completely and cannot teach values, beliefs, sense of belongingness, and self (Felix, 2020). It involves modeling human thought processes and designing machines to mimic human behavior and decision-making. With the use of AI technology, a teacher can automate his systematics work such as assigning daily mock tests, making reports, students' attendance, etc, and can save time and energy to focus on research and non-systematics tasks, leads to making better generation with natural intelligence. They can perform those tasks that a robot cannot perform (Fitria, 2021).

2.1. RESEARCH GAPS AND NEEDS OF THE STUDY

Identifying research gaps involves analyzing patterns, trends, and the distribution of research across various dimensions (e.g., topics, journals, geographic distribution, trends) to highlight underexplored areas in the existing literature.

2.2. RESEARCH OBJECTIVES

The main objectives of the study are given below

- 1) To identify influential publications, authors and impact.
- 2) To explore citation dynamics and trends.
- 3) To investigate the application areas of AI in Education.

3. RESEARCH METHODOLOGY

3.1. SOFTWARE AND TOOL USED

The current study engaged the Web of Science and Scopus database for the analysis. This study employed bibliometric Analysis for creating knowledge maps using Bibloshiny software of R studio through co-citation and co-authorship analysis.

3.2. DATA EXPLORATION AND KEYWORDS

Bibliometric analysis consists of four key stages: data collection, data preprocessing, statistical computation, and application analysis. A crucial step before conducting any bibliometric study is the selection of relevant keywords, which form the foundation of the analysis. To ensure a comprehensive study, researchers gathered over 100 papers—comprising both recent publications and highly cited works—from the Web of Science (WOS) and Scopus databases. These articles were used to identify significant author keywords that were deemed relevant to the topics “Artificial intelligence” and “Education.” Subsequently, these keywords are employed in various combinations throughout experimentation, resulting in the final search query string as given in Table 1. The writers diligently preserved the ultimate search query and compilation of the papers for future reference.

Table 1: Steps for Bibliometric Analysis

Stage 1: <i>Data Retrieval</i> - Selection of Research Database Result - Web of Science and Scopus
Stage 2: <i>Selection of Time Period</i> Result -1999 to 2025
Stage 3: <i>Data Loading</i> - Identification of the literature based on the selected keywords TITLE-ABS-KEY (("Artificial Intelligence" OR "AI" OR "Machine Learning") AND ("Education" OR "Learning" OR "Teaching" OR "Online Learning" OR "E-learning" OR "Higher Education" OR "EdTech" OR "Digital Learning") AND ("Intelligent Tutoring" OR "Adaptive Learning" OR "Educational Data Mining" OR "Learning Analytics" OR "AI in Education" OR "AIeD" OR "Personalized Learning" Result: 9075 Documents from both Scopus and Web of Science

Stage 4: <i>Data Cleaning</i> - Filtering the extracted data based on language, area, publication status and type of publication. Limit to Document type - Article and Review paper Limit to Language - English Limit to Source Type - Journal Limit to Publication Stage - Final Result: 4075 Documents
Stage 5: <i>Data Extraction</i> - Data is Extracted in the CSV format on the - Citation information, Bibliographical information, Abstract & Keywords
Stage 6: Combining the data of both database Scopus + Web of Science and Removal of Duplicate documents Result: 3096 Documents
Stage 7: <i>Data Analysis</i> - Using Bibliometrix R Software - Biblioshiny
Stage 8: <i>Analysis Techniques</i> - Performance Analysis and Science Mapping

Source: Authors' Compilation

4. ANALYSIS

This section of the study addresses the previously stated research questions about the artificial intelligence in education. This area exclusively focuses on publications that provide high-quality analysis and provide outstanding results, therefore offering crucial future suggestions.

4.1. RESEARCH GROWTH AND RECENT DEVELOPMENTS

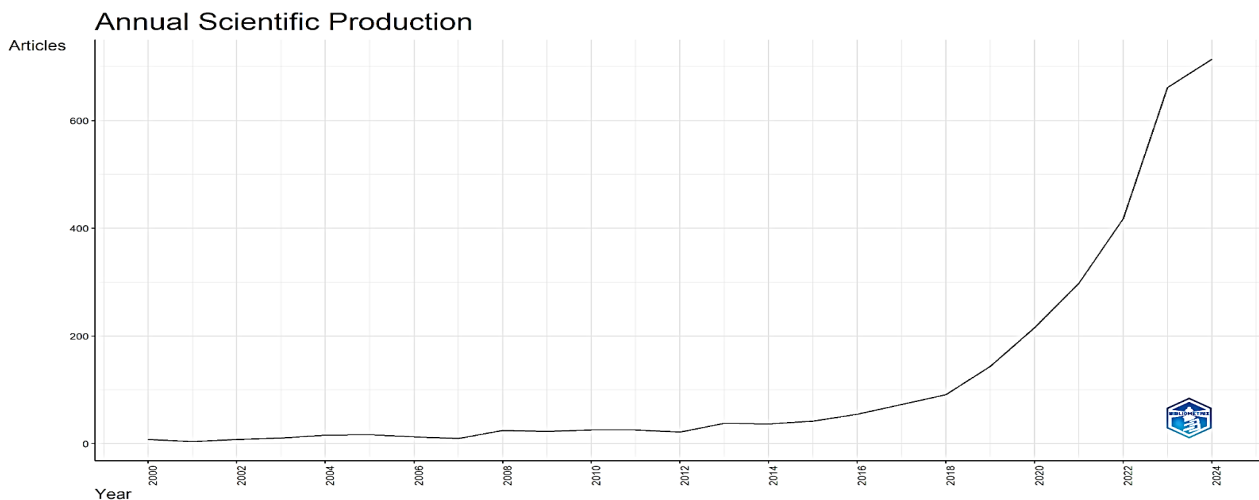


Exhibit 1- Annual Scientific Production

Source - Author's own

Exhibit 1 - "Annual Scientific Production" illustrates the chronological distribution of published publications from around 2000 to 2024. The vertical axis denotes the quantity of published scholarly articles, while the horizontal axis denotes the years. The graph shows a steady but relatively low level of scientific production in published articles from around 1999 to approximately 2016. After 2016, there is a significant surge in the number of published research paper

or articles, which accelerated sharply from around 2018 onwards. This trend continues to rise steeply through 2024. The exponential growth in scientific production starting around 2018 suggests a growing focus on the topic covered by these articles (likely AI in education, considering your earlier context).

The significant increase may suggest variables such as heightened financial resources and expanded attention toward artificial intelligence and education. Advancements in technology enhance the feasibility of study in this sector. An increasing number of scholars are making noteworthy contributions to the discipline, suggesting its development and enlargement. The swift upward trajectory of growth shows a dynamic and burgeoning field of study, implying substantial progress and breakthroughs in artificial intelligence. Furthermore, it might suggest potential prospects for additional investigation and advancement as the discipline maintains its expansion.

4.2. PROFILIC JOURNAL AND CITE SCORE

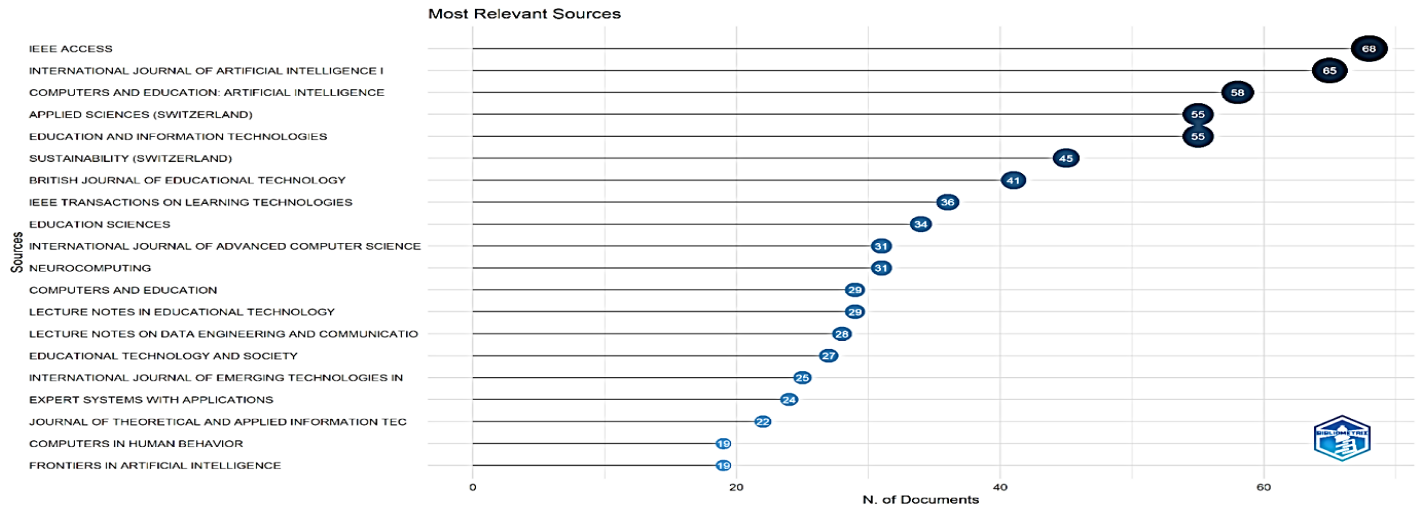


Exhibit 2: Most relevant journals

Source: Authors' Compilation

The results indicate that various publishers publish prolific journals the AI in Education. In Exhibit 2- Most relevant journals. As drawn from the data in the "Most Relevant Journals", is a concise overview of the most noteworthy sources in the domain of AI in education, categorized by the quantity of published papers. The top journals reflect a strong focus on the practical and theoretical aspects of AI in education, suggesting a well-rounded research environment. Infact several sources like "Sustainability" and "Applied Sciences" indicate that AI in education is an interdisciplinary field, touching upon sustainability, psychology, human behavior, and broader applications. The Journal-IEEE ACCESS has 68 articles. That represents a highly recognized journal that includes broad areas of topics, including applications of AI in education. total 65 articles are published in the International Journal of Artificial Intelligence in Education that focuses on the intersection of education and artificial intelligence, exploring innovative AI-based educational tools, techniques, and methodologies. Computers and Education: Artificial Intelligence has 58 articles on the application of AI in education, emphasizing the impact of computational technologies in learning environments. The Journal-Applied Sciences (Switzerland) has 55 articles: Covers a broad spectrum of applied sciences, including AI applications in education. Education and Information Technologies has 55 articles that indicate importance of technology in education, including AI-driven solutions and their implications. The Sustainability (Switzerland) has 45 articles that explore sustainable practices, including use of AI in promotion of sustainable educational methods. The British Journal of Educational Technology has 41 articles regarded as research sources for technology application in education, including AI. IEEE Transactions on Learning Technologies has 36 articles concentrating on innovative technological approaches to learning, including AI. Education Sciences has 34 articles that examine various educational sciences, including AI integration in learning. International Journal of Advanced Computer Science and Applications has 31 articles that discusses advanced applications in computer science, including AI for educational purposes.

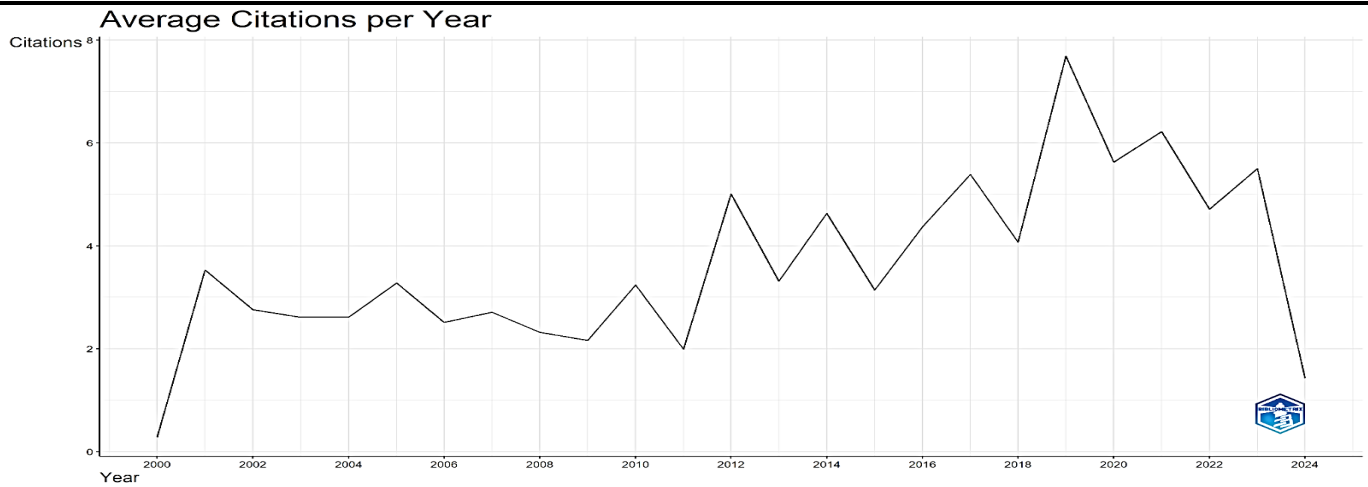


Exhibit 3- Average citation per year

Source; Authors' Compilation

Exhibit 3- "Average Citations per Year" highlights average citations of each article from 1999 to 2024 that shows a fluctuating trend over the years. There is no consistent upward or downward trend, but rather a series of rises and falls. In year 2000 to 2010, the average citations per year showed a generally stable pattern with minor fluctuations. The values remain between 2 to 4 citations on average per year, suggesting moderate interest and recognition of the published articles. In the years 2010 to 2012, a noticeable spike in average citations is observed around 2012, indicating that some articles published during this period gained significant attention. In years 2012 to 2018, there is a drop followed by further fluctuations, with peaks around 2016 and 2018, reflecting varying levels of citation impact in different years. The graph shows another peak around 2022, suggesting a period when articles received relatively high average citations. The fluctuations indicate that the impact of research articles in this field, as measured by citations, varies significantly from year to years. Peaks in average citations may correlate with particularly influential studies or breakthroughs in AI in education that garnered widespread attention in certain years.

4.3. EMERGING AND GROWING TRENDS OVER THE YEAR FIELD OF AI IN EDUCATION

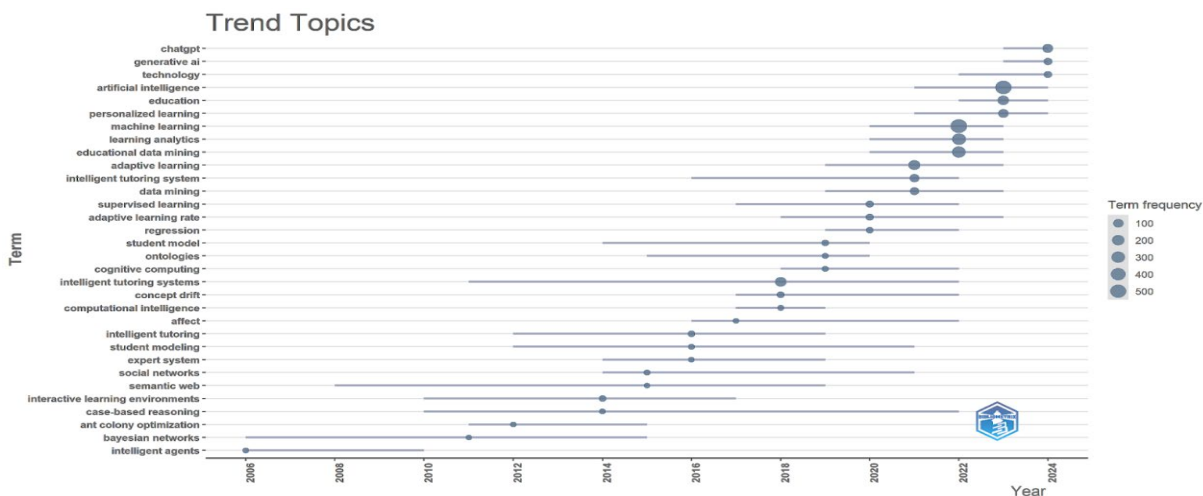


Exhibit 4: Topics in trend over the year

Exhibit 4 shows the frequency of various research topics in the field of AI in education over time. The y-axis represents specific terms or topics, while the x-axis shows the years. The size of each circle represents the term's frequency, with larger circles indicating higher frequencies. The appearance of these new terms reflects the dynamic nature of the field and underscores the importance of keeping abreast of technological advances. In recent years 2023-

24 ChatGPT and Generative AI have emerged prominently that indicating a sharp increase in interest and research in these areas. Personalized Learning, Learning Analytics, Machine Learning, and Artificial Intelligence have also seen significant growth in frequency, reflecting a steady rise in their importance within educational research.

Technology, Education, Artificial Intelligence, and Machine Learning have been consistently relevant topics over a longer period, indicating their foundational importance in the research field of AI in education. Intelligent Tutoring System and Adaptive Learning have also maintained a consistent presence, reflecting ongoing interest and development in these areas. Terms like Data Mining, Educational Data Mining, Supervised Learning, Regression, and Student Model have seen fluctuating but generally increasing attention, highlighting their technical significance in applying AI methods to educational data.

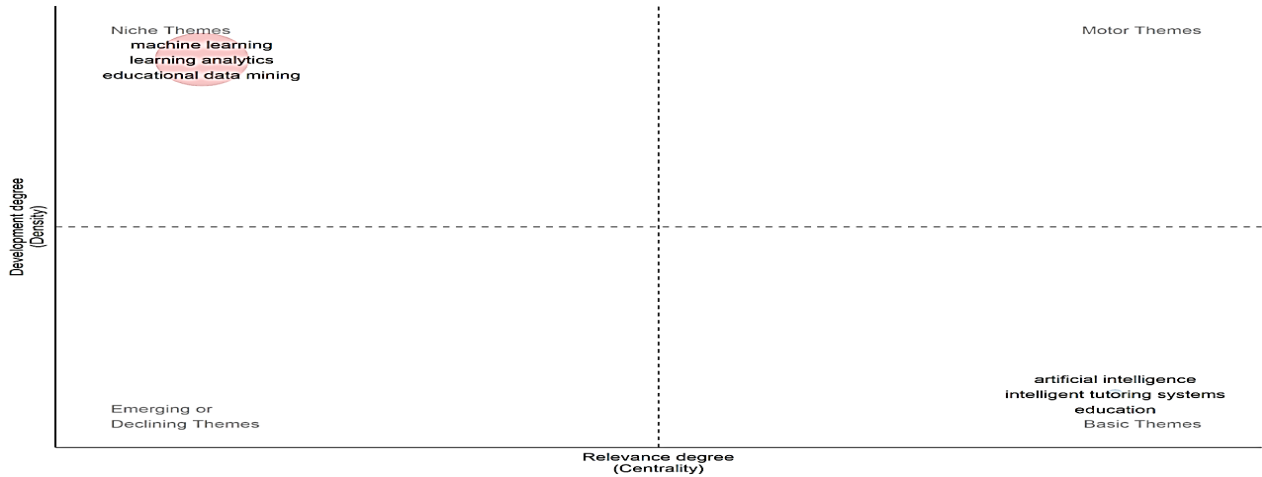


Exhibit 5- Thematic Map in field of AI in education

Exhibit 5- visualizes different research themes in the field of AI in education based on two dimensions: Relevance Degree (Centrality) and Development Degree (Density). These dimensions help categorize topics into four quadrants: Motor Themes, Niche Themes, Basic Themes, and Emerging or Declining Themes. **I Quadrant -Motor Themes (Top Right Quadrant):** This quadrant is empty, indicating that there are currently no themes identified as both highly relevant (central) and highly developed (dense). Motor themes are typically well-established areas that are both essential and actively growing within a field. **II Quadrant-Niche Themes (Top Left Quadrant):** In this quadrant topics like Machine Learning, Learning Analytics, and Educational Data Mining suggesting they are specialized, with high development (density) but lower relevance (centrality) in the broader research context. This means they are well-developed and may represent specialized areas of intense focus, possibly appealing to a narrower audience or subfield within AI in education. These areas may involve sophisticated methodologies and are likely to represent cutting-edge research focused on specific problems or applications in AI and education. **III Quadrant Basic Themes (Bottom Right Quadrant):** In this quadrant topics like Artificial Intelligence, Intelligent Tutoring Systems, and Education indicating they are highly relevant (central) but not as developed (dense) compared to niche themes. Basic themes are foundational to the field, serving as core areas of study but may require further exploration, depth, or advanced methodologies. **IV Quadrant Emerging or Declining Themes (Bottom Left Quadrant):** This quadrant is also empty, suggesting that no themes in the current analysis are both underdeveloped and of low relevance. Emerging themes are new and less established, while declining themes might be losing relevance.

4.4. ARTIFICIAL INTELLIGENCE INTEGRATION IN EDUCATION

1) Personalised Learning

One of the aims of AI is to provide personalised learning experience to the students. Every student is different, so AI caters their expectations by facilitating them unique learning material and solutions. Sustainable education requires rethinking the methods and learning outcomes of the education. Some interactive learning platforms facilitates personalised learning such as AI driven ACTIVE Math, Why2Atlas and MATHia. These platforms manage the learning achievements, also take of performance tracking, provide support to the students as well as to the instructors.

2) Immersive Learning

We can create new content with Generative AI in any form such as text, videos and images. The generative AI has immense potential in education. With the help of AI simulated environment can be created for providing immersive learning experience to the students. One can develop interactive educational content which makes study more interesting and easy (T. Wang et al., 2023). SweetRush, ELB Learning and Learning pool are the examples of immersive learning platforms.

3) Automation and Grading Assessment

These days administrative tasks consume a lot of time and energy of the teachers. With the help of AI, teachers can automate those administrative tasks, so that teachers can focus on personalised instruction and students mentoring (Zhang & Begum, 2023). Assessment system can be automated with AI, this automation can analyse every student response and also real time feedback can be provided. This automation can save a lot of time of teachers. ExamBuilder, DigiExam, FlexiQuiz and many AI based platforms are available for this purpose. There are some subjective and open ended tasks which can be graded automatically with the help of AI and it also provides consistent results (Xu & Ouyang, 2022).

4) Intelligent Tutoring System

An intelligent tutoring system (ITS) is basically a computerized programme that acts like a human tutor. This ITS presents customised instructions immediately to the learners. This system does not require any kind of human intervention. However, ITS provides data based insights to the teachers, which gives important insights related to student's performance, engagement and emotions. The teachers can modify their teaching methods according to those valuable insights. A teacher can intervene to provide better understanding (Lin et al., 2023).

5) Chatbots and virtual assistants/Mentor

Mentoring means to provide students one to one support. But time and resources are limited. So, the use of AI as virtual mentor seems very promising, on the other hand, it requires a deep understanding of the technology (Neumann et al., 2021). Virtual mentor is basically a multi media which poses the e-Learning environment that exhibits personalisation, interaction and intelligence (Zhang et al., 2016). Artificial intelligence has influenced the instructors as well as learners in STEM education, which results in changes in educational practices. When instructors use AI in STEM education, their role shifts from a leader to a facilitator (Xu & Ouyang, 2022). Many educational technology platforms are using AI as a Virtual Mentor. Just like a tutor, virtual mentor provide feedback to the students, assign them practice questions and also recommends related study material to study.

6) Digital lessons and Smart interactive content creation

Anyone can develop lesson plans with the help of generative AI. A teacher can give specific objectives and requirements, generate a comprehensive lesson plan. These plans are well structured also. AutoClassmate, and Magic School tools are available for generating interactive lesson plans. The generative AI has revolutionised the initial teacher education level (Kehoe, 2023). The teacher education programs should include training modules regarding how to use AI tools to make teaching more interesting. This can be done at primary level. Training should be provided to the teachers so that they can use the generative AI effectively. Thus, we can see that AI has lots of scope in education beyond the above mentioned areas. After many years, AI may be integrated in our education system so well that it may become a part of our curriculum.

5. LIMITATIONS

Regardless of extensive efforts and effective use of software, there is still a possibility of some limits in any study, which is equally applicable to ours. An inherent constraint may be the limited journal space for articles, which restricts our ability to delve into the essential aspects of the bibliometric study rather than extensively exploring numerous topics. This study serves as the initial basis for subsequent investigations. Additional keywords can be used by other researchers in conjunction with ours and areas of interest. Furthermore, to the best of the writers' estimation, this study serves as the initial basis for subsequent investigations.

6. CONCLUSION

Integration of AI in education holds enormous potential. AI plays a catalyst role in learning and teaching transformation. The conclusion if this article is artificial intelligence has so much benefits and challenges also. It is evident that financial resources and expanded attention towards artificial intelligence and education started around 2017-18. Even, the research scholars are making noteworthy contribution to this discipline. Advancements in technology that enhance the feasibility of study in this sector. An increasing number of scholars are making noteworthy contributions to the discipline, suggesting its development and enlargement. The swift upward trajectory of growth suggests a dynamic and burgeoning field of study, implying substantial progress and breakthroughs in the use of artificial intelligence. Furthermore, it might suggest potential prospects for additional investigation and advancement as the discipline maintains its expansion. It is notable that there is shift in research focus towards more advanced AI technologies and their applications in education such as ChatGpt and generative AI. The appearance of these new terms reflects the dynamic nature of the field and underscores the importance of keeping abreast of technological advances. The presence of basic themes indicates areas that are crucial to the field but may still have room for further exploration and development. Ethical considerations are also important to keep in mind while developing education. AI promises a personalised learning experience, better student-teacher engagement, automation of administrative tasks and efficient resource employment. However, it is also important to understand and address the risks associated with and to provide equitable resource access. Making robust privacy policies and ensuring accountability also need to be decided. Now future is looking ahead and signaling us towards better integration of artificial intelligence with education.

7. FUTURE DIRECTIONS AND IMPLICATIONS

It is crucial for future directions that educational technology is not only related to innovations in technology but we should be concerned about the ethical, pedagogical, social, cultural and economic challenges of artificial intelligence in education. The paper can provide a roadmap for future research directions, encourage more interdisciplinary and inclusive studies, and emphasize the importance of developing new metrics, frameworks, and collaborations.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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