International Journal on Robotics, Automation and Sciences

The Impact of AI on Educational Content Creation: A Bibliometric Review of Trends, Influential Research, and Emerging Themes in Enhancing Access and Quality in Education

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Abstract - The research conducts a detailed examination of Artificial Intelligence usage in educational content development to identify its effect on teaching methods while making connections to SDG 4 about quality education. The bibliometric dataset comprised of 494 peer-reviewed publications from Scopus database (2005–2025) was used to conduct co-citation, co-word and trend analysis through VOSviewer for identifying intellectual structures together with thematic clusters as well as emerging research trajectories. The analysis shows a major growth in educational AI research following 2020 because institutions adopt adaptive learning systems and generate content automatically while using intelligent teaching methods. Self-regulated learning along with predictive analytics data mining and immersive learning environments and self-regulated learning formed the four strongest co-citation groups. A co-word analysis confirmed that the core words "e-learning," "learning systems" and "machine learning" function as fundamental components within this academic domain. The study outlines the main ethical and practical consequences which include algorithm-based bias together with data administration problems and unequal access to materials that that emphasize the value of developing AI systems consider diverse contexts. The paper presents practical guidelines for leaders in research and education institutions alongside government agencies which direct AI utilization toward productive results while supporting equality and academic integrity across all programs. The analysis presents a strategic plan that guides how to use AI innovation to develop inclusive educational systems which produce meaningful learning outcomes while sustaining their operations.

Keywords- Artificial Intelligence, Educational Content Creation, Bibliometric Analysis, Education Quality, Inclusive Education.

I. INTRODUCTION

Education Industry is undergoing a revolution with Artificial Intelligence (AI) in creating, personalizing and delivering of content. Thanks to the use of technologies like machine learning, natural language processing and large language models. AI allows for the automated creation of instructional material like quizzes, summaries or even textbooks, which considerably frees educators from their load in the work [1]. Constructing educational content through adaptive learning systems that modify their material according to student advancement leads to improved individualized teaching according to [2]. AI teaching assistants together with virtual tutors now possess the ability to provide tailored feedback as well as customized support that generates immersive and learner-directed educational contexts [3]. Furthermore, AI contributes in building autonomous learning solutions such as voice to text systems, AI captioning, and real time translation tools to widening the learning access among students with disabilities or unable to

communicate in the same language [4]. Additionally, the integration of AI in educational content creation also improved data driven decision making in the context of institutions that help better identify areas of learning bottlenecks and improve curriculum design [5]. The combination of innovation shows that AI transforms traditional educational constructs into systems that customize themselves to meet the needs of individual learners.

The United Nations Sustainable Development Goal 4 (UN SDG 4) seeks to achieve "inclusive and equitable quality education and promotion of lifespan learning opportunities aimed at securing quality learning in every child and adult." Today, AI is regarded as a strategic lever to help push progress on this goal even faster. AI can facilitate differentiating instruction in order to foster diversity in needs, which is to say, addressing the equality of access and outputs [6]. AI systems have shown success in erasing gaps in rural or under the resourced regions by providing low cost and scalable content delivery and localized learning environment [5]. Predicative learning analytics using AI applications can anticipate dropout risk for students and therefore enable educators with the means to provide targeted support to students in order to reduce education inequality [7].

Through bibliometric review this paper examines the effects of AI on educational content development and its connection with SDG 4. The study examines current trends together with influential authors and progressing research themes by implementing trend analysis and co-citation and co-ward analysis [8]. Through this research researchers will examine how AI supports the accomplishment of SDG 4 by creating individualized programs and offering improved accessibility and enabling educational programs to scale efficiently [9]. [10]. Research distribution analysis will be conducted to show how AI innovations spread between different global regions since [11] investigated this aspect. This paper intends to explore the following research objectives:

1. To analyze publication trends over time in AI-driven educational content creation.
2. To identify influential authors and research clusters through co-citation analysis.
3. To detect emerging themes and keyword relationships using co-ward analysis.

This paper uses these dimensions to enrich the comprehension of both academic research and practical aspects in educational AI applications in global contexts.

II. LITERATURE REVIEW

A. AI in Education

The rapid changes in educational systems because of Artificial Intelligence (AI) bring forth new innovative tools that both create content material and personalize learning while improving accessibility for students. For example, one of the AI based adaptive learning systems that uses algorithms to change the difficulty of a task and content real time according to the learner's performance. The customized system enables tailored educational journeys for students which benefits classrooms containing different student educational requirements. Machine learning, natural language processing and deep learning make it possible to develop personalized educational experiences that alter dynamically to hear students' needs and let every parent to go through the pace [12]. AI tools provide education institutions with automated systems that both grade students and track their performances thus enabling teachers to dedicate time to mentorship and interactive education activities. By using artificial intelligence, the generation process becomes automated to develop adaptive textbooks and quizzes which are specifically tailored to meet individual student abilities and give immediate feedback for better learning retention [13]. In addition, speech to text, language translation, and voice assistants has made accessibility in education easier with the help of artificial intelligence. The tools support education accessibility because they offer transcription services and visual explanations for challenging subject matter to students who have hearing difficulties [14]. The analytics capabilities of AI systems enable educators to monitor student progress thus enabling them to schedule timely assistance for students who need it [3].

B. AI in Educational Content Creation

The use of AI in educational content creation has changed the game because it has led to creation of dynamic, interactive and adaptive content that is inclined to individual learners[15]. The AI driven platforms such as smart tutor, content generator, and interactive textbook make it possible for personalized learning experience where the platform would adjust according to the changing needs of the learner. Intelligent tutoring systems (ITS) for example, adapt to different rate of progress of students by varying difficulty levels in real time, giving hints and generating immediate feedback. For example, in the domain of mathematics and language acquisition, it can be shown that these systems have had significant success in creating learners with varying needs [16]. Moreover, textbooks and other educational resources generated by AI are always updated automatically according to the most recent discovery [17]. In addition, AI driven platforms promote social learning that makes students connect with other people, have group discussions, and enhance with their learning experience. Especially in ChatGPT type platforms that can be used as a collaborative assignment tool, giving students the opportunity to develop a deeper understanding of the subject by engaging with peers [18][19]. AI has become an essential educational tool because its content adaptation and distribution capabilities benefit modern teaching environments

particularly those with many students and different educational profiles [20], [21].

C. The Role of AI in Realizing SDG 4: Quality education

The advancement of SDG 4 regarding inclusive quality education depends significantly on AI implementations. At the same time, AI not only facilitates the personalized experiences of learning but also offers the personalized experiences of educational delivery to accommodate the diverse needs of students that particularly in low resource or underserved areas. Modern AI learning technology through adaptive systems provides education infrastructure that adapts learning content delivery according to individual students so they obtain their proper learning challenges together with necessary academic assistance leading to improved educational achievement [12]. In addition to that, there is an aspect of digital divide bridging, AI can also provide low-cost solution for democratizing access to education, especially in remote and rural areas where the traditional educational infrastructure is not accessible. Virtual classrooms, online tutoring, learning management systems are among the AI tools which make sure that there is no scope of low quality of education despite of location of the learner [22]. Moreover, AI can help with inclusive education by delivering assistive technologies that allow the students with disabilities to engage with the process of education. These include text-to-speech for the visually impaired students and voice recognition for the hearing-impaired students, for example, to enhance all the learner's access to the quality education [23]. Real-time feedback, data analytics and timely intervention to students having issues in their learning is also provided by these AI driven systems [17]. By having these various innovations, AI is very much vital to obtain SDG 4 as it helps in advancing the reach and quality of educational opportunities all over the world [24].

D. Present study

The current educational literature defines several areas where AI applications need additional research concerning their implementation. Research today fails to adequately assess the moral consequences of AI adoption because it does not address the challenges AI presents to data protection and shows risk of producing discriminatory results and perpetuating discriminatory systems. Research devoted to AI technical features disregards analyzing social problems resulting from its national implementation. AI tools will increase their classroom presence requiring developers to establish transparent systems which exhibit fairness while holding AI systems accountable for their actions [13]. The second huge gap is that there is a lack of research on how AI driven educational content would impact the community in low resource and marginalized one. The research community needs to study AI implementation strategies for basic digital infrastructure zones as studies currently concentrate on urban and well-supported educational systems [16]. Research must expand its focus to investigate the permanent impact of artificial intelligence applications upon student results for engagement levels and knowledge accumulation and academic achievement metrics. The prolonged effects of AI on student learning and personal development require further investigation according to [25]. The current research fails to address implementation issues related to AI usage across different educational environments [26] mainly because these institutions do not possess the appropriate technological foundation needed to harness AI tools effectively.

III. METHODOLOGY

A. Bibliometric Approach

In this study, bibliometric approach is adopted to systematically study such trends, co-citations and keyword patterns in the field of AI driven created educational content. The quantitative research method known as bibliometrics lets researchers establish a pictorial structure of academic literature published in specific fields. This paper evaluates AI education research development through the examination of key publications and authors and major research directions that are emerging. Use of Scopus and VOSviewer tools in this analysis provides enhanced capabilities to identify major trends and relationships in the literature according to [1] and [16].

B. Stage 1: Data Collection

The process of collecting data occurred through Scopus which maintains one of the largest academic article archives that serves disciplines in computer science, education and artificial intelligence. The selection of Scopus derived from its comprehensive peer-reviewed content coverage and comprehensive citation management features[16]. The search executed through Scopus database on April 1st, 2025 secured the latest research content for evaluation. A well-designed search query served as the basis for document selection to identify AI studies focused on education aspects of content creation and personalization and adaptive learning methods. The search query used was as follows: TITLE-ABS-KEY ("artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "AI systems") AND TITLE-ABS-KEY ("education" OR "learning" OR "teaching" OR "pedagogy" OR "online learning" OR "digital education" OR "learning technology") AND TITLE-ABS-KEY ("personalized learning" OR "adaptive learning" OR "educational content" OR "automated content generation" OR "intelligent tutoring" OR "learning systems" OR "educational technology") AND TITLE-ABS-KEY ("accessibility" OR "inclusive education" OR "assistive technology" OR "learning tools" OR "learning analytics" OR "student support systems" OR "educational equity") AND TITLE-ABS-

KEY ("digital learning" OR "AI-driven education" OR "smart classrooms" OR "online education" OR "e-learning" OR "technology-enhanced learning").

C. Stage 2: Screening Process

The obtained 505 documents underwent a methodical scrutiny phase to isolate studies that met both the high standards of quality and the setting criteria for analysis. All included articles needed to meet three requirements: peer review status, English language publication and date range from 2005 to 2025. Every paper included within the study requires direct connections to AI applications in education with a specific focus on topics like content creation and personalized learning and adaptive learning systems. Articles about theoretical AI concepts without practical applications or those lacking educational content creation were eliminated from consideration. This initial assessment led to the selection of 494 documents which formed an adequate foundation for bibliometric analysis.

D. Stage 3: Analyzing the Data

The software tool VOSviewer served as the main application for both co-citation and co-word analysis. [27].

Co-citation Analysis

To identify AI in education papers and authors, co-citation analysis is applied. This is a technique that studies the frequency with which two articles are cited together in the literature and thus shows the seminal works underlying the research clusters. Co-cited articles often have a strong relationship in terms of the topics the articles address or the methods they use, and these relationships can also show important collaborations and key authors in the field [16]. This analysis relied on the VOSviewer tool for use, visualizing the co-citation network and discovering clusters of research that have made some considerable impression on AI research in educational content creation [27].

Co-word Analysis

The relationships between keywords selected for the articles were studied using co-word analysis. The beneficial effect of this method is that it facilitates the identification of research topics that have not been advised yet. Among these keywords such as "personalized learning", "adaptive learning system", etc. appeared to capture the major themes in the literature. This analysis offers a set of insights of how the field is developing, specifically signaling some of the new areas of attention. Co-word analysis also helps identify the common research areas in AI and education and how new topics like AI powered tutoring systems and educational accessibility have taken their place [16], [17].

IV. RESULTS AND DISCUSSION

A. Trend Analysis

Figure 1 shows the trend analysis of publications of AI-driven educational content creation over the past two decades with considerable research activity. From 2005 to 2014, the focus of scholarly attention to the topic was modest, publishing below 10 papers per year. For example, in 2010 only 4 documents were indexed in Scopus supporting the fact that artificial intelligence has yet been integrated in the form of educational content development. The early research period was especially exploratory; it centered around foundations of AI and its theoretical opportunity for use in the pedagogical setting. During 2015 the beginning of gradual growth took place, at the same time as
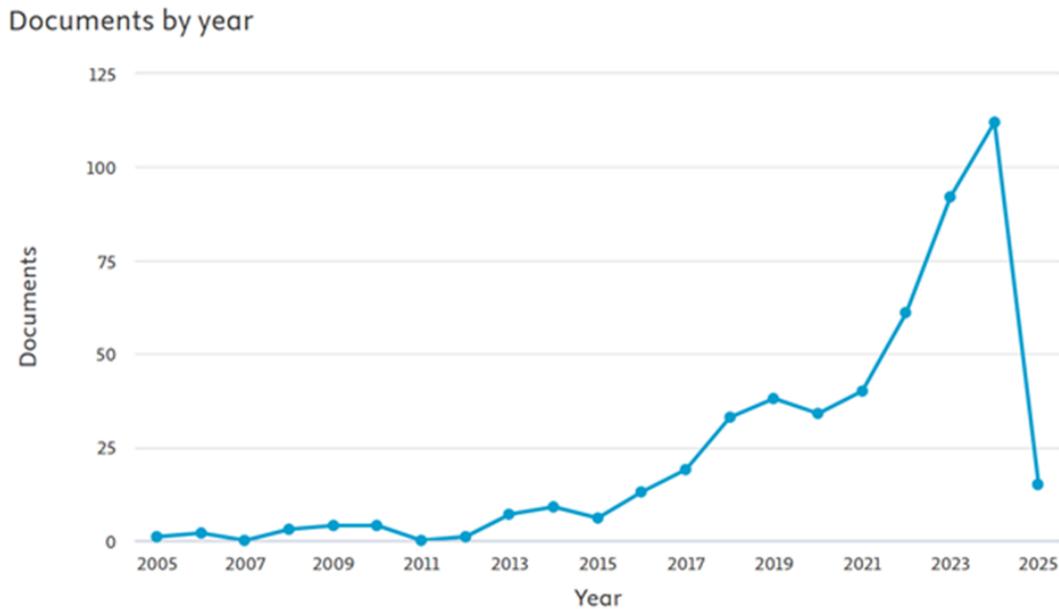
Documents by year

FIGURE 1. Number of publications and citation between 2005 and 2025. (Source: Scopus.)

technological advancements in machine learning and natural language processing. From the late 2010s on the number of publications steadily increased. In 2018, the number of documents rose to roughly 33 and has also increased to 38 in 2019 and 34 in 2020. The increasing number of scholarly contributions indicates that researchers are increasingly interested in applying AI technology for individualized education approaches and computerized evaluation and digital educational content development [28]. From 2021 on, it is a matter of record that the surge in research marked that dramatic rise: 40 in 2021, 61 in 2022 and 92 in 2023. The growing number of studies in this field demonstrates both the development of artificial intelligence education approaches and increasing institutional requirements for automated inclusive learning systems [13]. In 2024, when there are 112 documents, we witness a peak in interest in AI for its use in education because of technological readiness and institutional receptivity to it for the purpose of improving content quality and accessibility.

The observed decrease of documents to 15 in 2025 needs further examination before reaching a conclusion. The decrease in documents does not reflect lowered interest or reduced activity since the data retrieval occurred early on April 1st, 2025 before substantial publication of 2025 content. When performing the final screening stage researchers eliminated additional documents that stemmed from the initial search results. The actual number of publications in 2025 should increase during the upcoming months of the year.

The dataset in Figure 2 illustrates how many documents each nation has distributed. The United States stands at the forefront with 75 documents and then comes India which has 57. The research shows China and Germany rank after the United States while having 43 and 38 documents respectively. Spain has
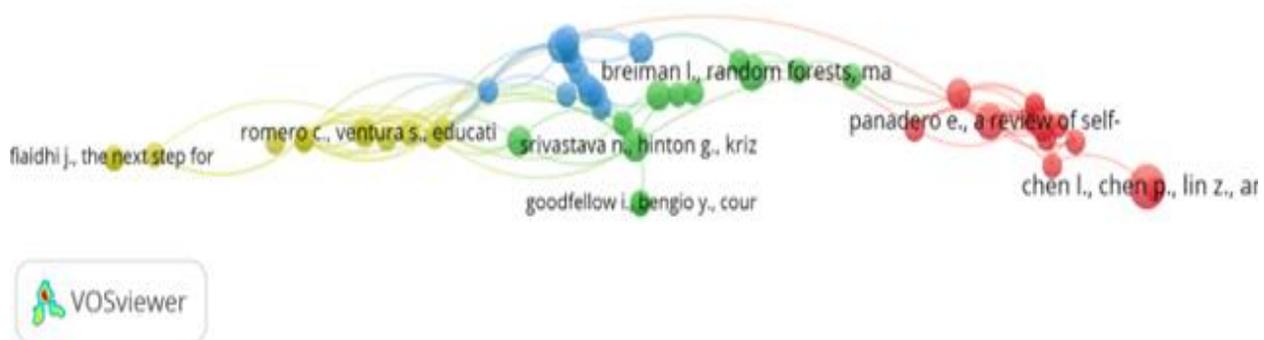

FIGURE 3. Cocitation network mapping of key references in learning analytics.

37 documents and the United Kingdom maintains 36 documents among their total documentation. Other nations including Saudi Arabia, Italy, Australia and Japan exhibit fewer published documents which fall between 21 and 23.

The United States maintains extensive dominance with twice as many documents as Japan while India closely follows the United States with a conspicuous distance between both countries. Categorically these countries display different document counts which reflects how actively their communities engage with the subject topics embedded in the documents. The United States maintains a definitive content document lead possibly because it produces more content or because it possesses extensive data availability yet other countries mainly contribute content through emerging economies such as India and China.
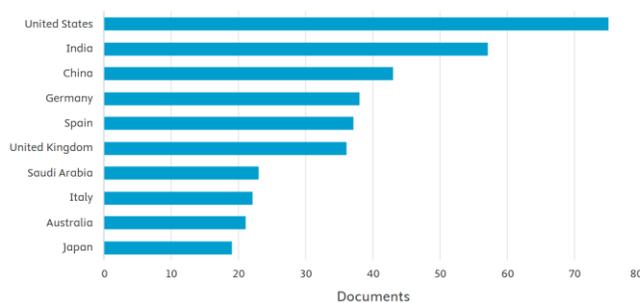

FIGURE 2: Documents by country

B. Co-Citation Analysis

Of the total of 15,387 cited works, 55 fulfilled the set threshold of 3 citations and were all cited by the same co-citation analysis clusters. In grouping these, research found four distinct clusters that reflected core educational AI in education domains: educational content creation, learning analytics, and machine learning in pedagogy, with several of which had high impact and were highly connected in the scholarly network as shown in table 1. In particular, the authors with the highest total link strength (19) were [29], who've made a remarkable contribution on self-regulated learning. Similarly, both [30] and looked into strong linkage between learning models (16) and open university analytics (16). Further frequently cited references in relation to the conceptual foundation of AI in education included [31], [32], [33] [34]publication. The sources provided are used to create a network analysis as shown in figure 3 presents the ten references that co-cited the highest with the greatest total link strength.

The student success prediction task benefits from the SMOTE technique which [35] first presented in the literature. Research on student success prediction by MOOC learners and affective feedback systems was conducted by [33] alongside [36]. The key takeaway from this cluster is that there is a technical foundation to AI in educational tools, designed to predict learning outcomes, catch a risk, and distribute the content accordingly.

Cluster 1 (Red Cluster): Self-Regulated Learning and Pedagogical Foundations

The first cluster includes 13 references organized under themes of metacognition, self-regulated learning (SRL), feedback and learning strategies. [31] examines metacognition during hypermedia learning and [37][37]analyze thematic psychology processes. These works also afford learning as a pedagogical understanding of learners' management and reflection of learning processes. The research by [38] gave an extensive breakdown of AI applications in education through the combination of adaptive learning systems and intelligent platforms that enable individualized instruction . [39]include the importance of feedback in terms of educational effectiveness while [29] serve to emphasize that one related to academic achievement is the relationship between SRL and academic achievement. In support of human centered, cognitive behavioral foundation of AI content integration, this cluster emphasizes the typical student agency and learning autonomy technologies.

Cluster 2 (Green Cluster): Machine Learning Models and Predictive Analytics

The references in Cluster 2 extend across twelve items which focus on machine learning techniques and predictive modeling alongside risk detection in MOOC performance. [40]demonstrated Random Forests while [41] defined deep learning as the basis for educational AI algorithm development. An overview of how deep learning works with educational datasets appeared in the [34]publication. The student success prediction task benefits from the SMOTE technique which [35] first presented in the literature. Research on student success prediction by MOOC learners and affective feedback systems was conducted by [36].The key takeaway from this cluster is that there is a technical foundation to AI in educational tools, designed to predict learning outcomes, catch a risk, and distribute the content accordingly.

Cluster 3 (Blue Cluster): Learning Analytics and Educational Data Mining (EDM)

Research about learning analytics (LA), EDM and data visualization appears in 12 documents in Cluster 3. The basic foundations of current LA/EDM applications in higher education originate from two major works published by [42] and Siemens and [43]. The academic community adopted Latent Dirichlet Allocation (LDA) as presented by [44] for mainstream topic modeling in education research. [45], [46] developed foundational structures that outlined the integration process of analytics at both policy and conceptual levels for institutional frameworks. This segment brings together theoretical and practical elements through which analytics serve dual functions as metrics of learning as well as effective educational system development. [46], [47]join the research to

address concerns about ethical dimensions and conceptual aspects tied to analytics which include data privacy and student ownership of data.

Cluster 4 (Yellow Cluster): Early Intervention and At-Risk Student Modeling

The twelve references in Cluster 4 focus on early warning systems and learning intervention strategies and dropout prediction models as their main areas of interest. The practical applications of student retention strategies and support at Purdue University are highlighted in [48], demonstrates early identification system models. The application of neural networks within the context of MOOCs was showcased by [49] at the same time [50] applied analytics strategies to engineering student performance. A review of evolving learning analytics in higher education institutions was presented by [51]. The institutional application theme of this cluster reveals its main goal of implementing AI tools for proactive student support systems targeted at students who struggle in open and distance learning environments.

TABLE 1: The top 10 documents based on their co-citation and total link strength

No.	Documents	Citation	Total link strength
1	[29]	4	19
2	[30]	6	16
3	[33]	3	16
4	[31]	3	15
5	[52]	3	15
6	[32]	3	14
7	[50]	3	14
8	[43]	3	13
9	[53]	3	13
10	[54]	3	12

C. Co-Word Analysis

A co-word analysis conducted within VOSviewer discovered the major themes along with their discourses in AI-powered educational content creation. A total of 40 keywords passed the study threshold when each occurred at least 18 times among 3,743 extracted keywords. This evaluation included keyword occurrences for frequency measurement and total link strength as an indicator of keyword co-appearance frequency that determines network relational strength between key terms. Throughout literature e-learning remains the most important concept because its frequency reaches 378 and its links to other keywords reach 2002. The top 15 keywords are shown in Table 2. Figure 4 depicts the network structure of keyword co-occurrence relationships.

TABLE 2. Keyword co-occurrence analysis top 15 keywords.

Rank	Keyword	Occurrences	Total Link Strength
1	e-learning	378	2002
2	learning systems	345	1837
3	students	203	1336
4	learning analytics	144	932
5	machine-learning	157	905
6	artificial intelligence	162	824
7	computer aided instruction	114	770
8	education computing	80	592
9	learning analytic	76	533
10	data mining	71	529

Cluster 1 (Red Cluster): Pedagogical Innovation and Personalization

The 13 items within Cluster 1 emphasize both pedagogical improvements and personalized education and Artificial Intelligence adoption in organized educational settings. Research interests include adapting educational content to the individual needs and they are central terms, namely "artificial intelligence", "personalized learning", "curricula". E-learning and educational technology emerged as a result of the digital shift which affected higher and engineering education the most. Their articles show that changes in AI ethics (such as in use of keywords like 'federated learning' and 'adversarial machine learning') or decentralized personalization systems indicate streams that need to change. SDG 4 receives substantial support through this cluster because it promotes accessible learning situations which use adaptive technologies to make education more effective while keeping content modern.

Cluster 2 (Green): Learning Analytics, Data Mining, and Predictive Modeling

The technical basis of AI education in education appears in Cluster 2 through its 11 items which focus on data analysis and forecasting methods. 'Related strongly to keywords 'machine learning', 'data mining', 'learning analytics' and 'predictive analytics', meaning that instruction and intervention will be informed by student provided data.' This educational data mining cluster underscores strategic bulk data applications because it incorporates "educational data mining" and "decision trees" with "big data" analytics. The studies within this analyzer cluster focus on analytics applications for scalability and personalization which support key components of SDG 4 equity and quality objectives.

Cluster 3 (Blue Cluster): Instructional Systems and Student-Centered Technologies

The 8 keywords in Cluster 3 highlight the importance of interactive systems as they enhance the learning experience of students. The terms "students" and "student performance" and "learning analytic"
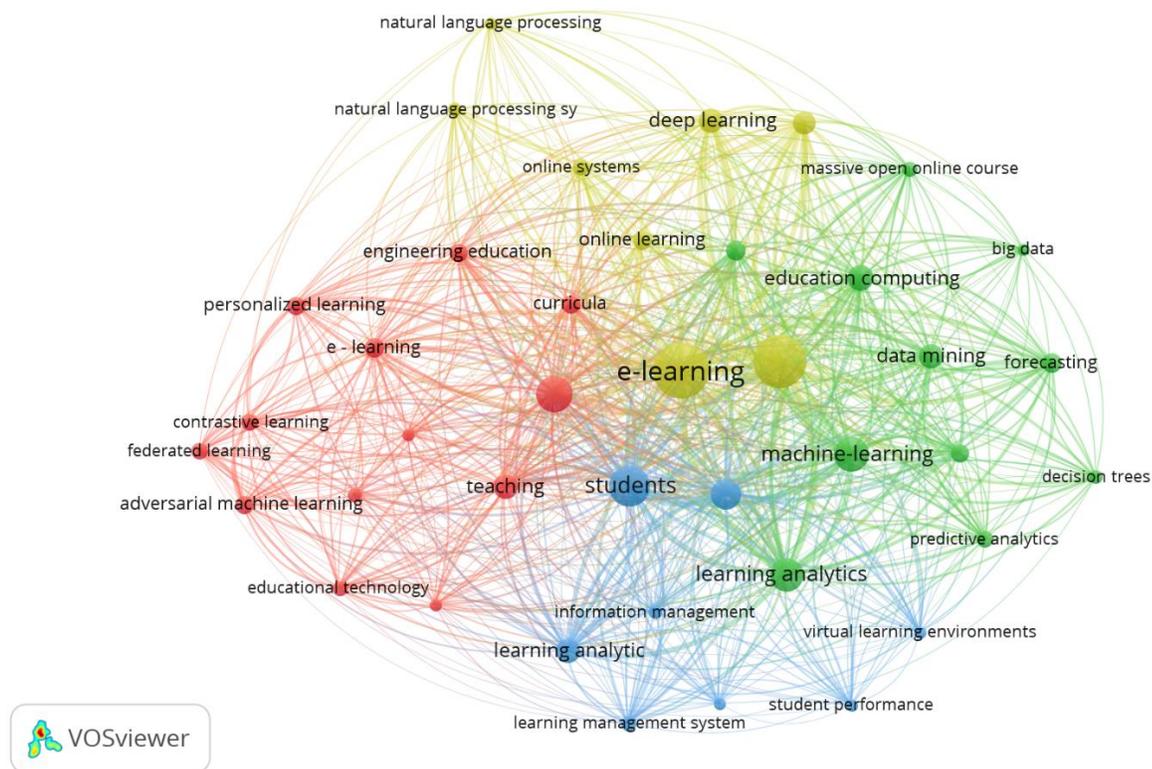
FIGURE 4. Keyword Co-occurrence Analysis of Educational Technology Literature (VOSviewer)

demonstrate an educational focus on learners whereas "computer aided instruction" together with "virtual learning environments" and "virtual reality" represent supporting educational technologies. The combination of "learning management system" with "information management" indicates that educational institutions need content platforms to improve both learners tracking capabilities and administrative system effectiveness. AI tools in this grouping establish relationships between improved student interaction and personalized teaching methods that generate positive effects on educational inclusiveness and quality.

Cluster 4 (Yellow Cluster): System Architecture and Digital Delivery

The 8-item Cluster 4 concentrates on infrastructure together with delivery platforms. Electronic learning and learning systems and learning algorithms and online learning make up dominant keywords which indicate how education systems have moved toward digital transformation. One of the notable mentions here is "deep learning", "natural language processing", and "online systems," all which refer to AI backed backend systems that allow you to auto content, chatbot tutor, and real time analytics via them. This cluster, despite being an abstraction of what lies beyond, is about this technological scaffolding that enables personal and accessible educational experiences. SDG 4 benefits from its capability to scale operations and create content which strongly supports education delivery within low-resource and remote environments.

V. IMPLICATIONS

A. Theoretical Implications

When it comes to content creation of educational content, Artificial Intelligence (AI) integration is happening so globally and rapidly that we need to rethink and redesign the basic learning theories and the pedagogical frameworks. AI, relatedly, has implications for theory regarding cognition, the learner autonomy, as well as instructional design. Educational research now faces the need for new educational methods which combine human mentorship with computer-guided instruction after adaptive learning computers began to automate student support by using standardized learner information [55].

In addition, AI tools such as intelligent tutors and content recommender systems also create additional loops of feedback upon each other which result in novel formulations of formative assessment theories, that instead of relying upon periodic testing, focus on real time, continuous learning evaluation [56].

Theoretical models that can serve the instruction through machine, must be used as these shifts need.

Critical theoretical engagement with equity frameworks is also an invitation AI makes to play a role in enhancing inclusivity and personalization. Now theories of educational justice must include how algorithmic systems may create or exacerbate educational gaps of access, language and ability [57]. Additionally, the incorporation of AI in language processing and universal accessibility brings with it some theoretical staples in multimodal learning and load in cognitive distribution, as in learners with disabilities or other learning preferences [58].

On the other hand, the idea of education's "agency" is also undergoing its theory. The integration of AI into educational mediation demands scholars to determine how learners can maintain control over their learning systems that incorporate predictive analytics and recommender systems [59]. It is essential to the way in which architecture will think about autonomy, authority, and the autodidact's evolving relationship with knowledge and content.

B. Practical Implications

The research data demonstrates how AI technology transforms educational processes while improving teaching methods and maximizing learning scale. Through the incorporation of the use of AI powered tools the tools which generated personalized content and learning analytics dashboards courses educators are able to personalize experiences for different demographics of students, thus increasing efficiency and inclusive [60].

This means that for educational institutions, infrastructure, faculty training and curriculum redesign must be invested in. The authors encourage policymakers to design national strategies that would facilitate responsible AI adoption in public and private educational systems of the public[61]. Specifically, they include creating AI ethics, data privacy and oversampling standards, especially in under resourced areas where the digital divide impedes the progress of AI.

Teachers also hold a significant impact mediation role with AI and hence teacher training has to involve digital fluency, ethical AI use, and pedagogical strategies for working with intelligent system [62]. In addition to adopting evaluation frameworks that transcend test scores, which need to include measures of student interaction, motivation, and personalized learning growth enabled by AI, administrators should also address those two specific research questions stated at the conclusion of prior discussions.

Additionally, the development of AI tools for real-time analytic learning allows institutional intervention prior to at risk students so retention rates and success outcomes are more likely improved [63]. On a global scale, the implementation of AI enabled education in alignment with SDG 4 goal requires large scale open access tools and policies that allow multilingual, inclusive as well as adaptive content delivery [23].

VI. Conclusion, Limitations, And Future Avenues

Bibliometric research analyzed the development of AI-produced educational content together with its conformity to Sustainable Development Goal 4's education objectives. The time period analysis demonstrated that research interest about AI education increased dramatically after 2020 because the worldwide community identified its transformative power. The co-word and co-citation analyses revealed three primary theoretical frameworks together with three main technological tools and three main research subjects that included self-regulated learning as well as adaptive learning and predictive analytics. Previous seminal contributions from other literature on personalized learning environments, ethical framework, and intelligent content delivery system also convey the role of AI in reshaping of pedagogy and advancement of digital equity. The research demonstrates that AI functions beyond its supportive role since it directly drives transformations to educational content along with curriculum development and instructional delivery systems. SDG 4 receives support from AI technology because its function to create scalable personalization and deliver real-time feedback helps address educational barriers such as resource disparities and learning inefficiencies and curricular rigidity [61].

Various restrictions emerge from conducting this bibliometric research although it generated important findings. The dataset included only English publications which appeared in Scopus between 2005 and early 2025 as a restriction so potentially important non-English or gray literature publications were excluded from study. Some critical studies related to policy or region focus receive limited visibility through this methodology. The bibliometric analysis methods co-citation and co-word mainly concentrate on mathematics-based relationship quantities yet lack ability to observe theoretical resource depth and contextual details. Highly cited publications tend to monopolize co-citation maps even when their current usefulness and practical value has waned according to [64]. The clustering process through co-word analysis depends on author-selected keywords because authors use words differently between various studies. The algorithm employed by VOSviewer demonstrates strong processing power yet tends to underestimate complex relationships between multi-disciplinary papers [65]. The review omitted assessment of policy environments together with cultural contexts and digital infrastructure in low- and middle-income countries although these determine the educational AI integration within these settings.

Research in AI-enhanced educational content creation needs to overcome the constraints described while studying various unexplored aspects. Research requires continued development of extended time period investigations to discover how AI-produced knowledge affects students' achievement and their

inclination toward learning as well as teachers' work function [66]. Additionally, research must explore proper ethical practices when implementing AI systems in various cultural contexts including multilingual education systems and locations with limited resources. The future frameworks must put emphasis on issues that stem from content bias as well as algorithmic fairness together with equitable AI benefits distribution [67]. Future AI tool development needs to implement user-centered design as its main development approach. Educational institutions and developers ought to work together with teachers and students to create AI technology solutions that serve practical instructional requirements and uphold ethical requirements for transparency along with data privacy [68]

Research should extend into new areas by conducting studies about diverse collaboration between education fields like AI in humanities and arts learning and different delivery systems for AI-based education like mobile and offline applications per [69] [70]. More investigation must be conducted to develop appropriate policies together with governance structures that will steer the use of AI in education[71]. Public institutions should develop guidelines describing how to build ethical systems and maintain accountability functions while creating funding standards for inclusive AI expansion across nations [72].

ACKNOWLEDGMENT

We want to thank peer reviewers for helping to review the paper.

AUTHOR CONTRIBUTIONSS

Valentine Kirimi Muriira: Conceptualization, Writing – Original Draft Preparation;

Venoth Nallisamy: Project Administration, Writing – Review & Editing;

José Manuel Saiz-Alvarez: Data Curation, Methodology, Validation;

Hussein Barabwd: Visualization, Supervision

CONFLICT OF INTERESTS

No conflict of interests were disclosed.

ETHICS STATEMENTS

Ethical approval was not applicable to this research since it did not involve human participants, animals, or sensitive data.

REFERENCES

[1] C.A.G. Cano and A.L.C. Troya, "Artificial Intelligence applied to teaching and learning processes," *LatIA*, vol. 1, pp. 2, 2023.

DOI: https://doi.org/10.62486/latia20232

[2] S. Ray and D.P. Ray, "ARTIFICIAL INTELLIGENCE IN EDUCATION: NAVIGATING THE NEXUS OF INNOVATION AND ETHICS FOR FUTURE LEARNING LANDSCAPES," *International Journal of Research -GRANTHAALAYAH*, vol. 11, no. 12, 2024.
DOI: https://doi.org/10.29121/granthaalayah.v11.i12.2023.5464

[3] T.K.C., "Artificial Intelligence for Education," *International Journal For Multidisciplinary Research*, vol. 7, no. 1, 2025.
DOI: https://doi.org/10.36948/ijfmr.2025.v07i01.36493

[4] N.V. Eziamaka, .T.N. Odonkor and A.A. Akinsulire, "AI-Driven accessibility: Transformative software solutions for empowering individuals with disabilities," *International Journal of Applied Research in Social Sciences*, vol. 6, no. 8, pp. 1612-1641, 2024.
DOI: https://doi.org/10.51594/ijarss.v6i8.1373

[5] R. Mission, R.J. Fio, A.R. Mission, "AI-Powered Pedagogy: Integrating Artificial Intelligence in Information Technology Education for Future Workforce Readiness," *Journal of Innovative Technology Convergence*, vol. 6, no. 4, pp. 69-86, 2024.
DOI: https://doi.org/10.69478/JITC2024v6n4a06

[6] D. Padua, "Artificial intelligence and Quality Education: The Need for Digital Culture in Teaching," *Journal of Educational, Cultural and Psychological Studies (ECPS Journal)*, no. 30, 2025.
DOI: https://doi.org/10.7358/ecps-2024-030-padd

[7] C. Timbi-Sisalima, M. Sánchez-Gordón, S. Otón-Tortosa and R. Mendoza-González, "Self-Assessment Guide to Quality in Accessible Virtual Education: An Expert Validation," *Sustainability*, vol. 16, no. 22, pp. 10011, 2024.
DOI: https://doi.org/10.3390/su162210011

[8] D. Arini and M. Nursa'ban, "Contribution of Artificial Intelligence (AI) in Education to Support the Achievement of Sustainable Development Goals (SDGs) 2030," *Jurnal Penelitian Pendidikan IPA*, vol. 10, no. SpecialIssue, pp. 39-45, 2024.
DOI: https://doi.org/10.29303/jppipa.v10ispecialissue.8321

[9] S.S.H.M. Adeel, "THE ROLE OF AI TOOLS IN LEARNING STRATEGIES OF PAKISTANI STUDENTS IN KARACHI," *Pakistan Journal of International Affairs*, vol. 7, no. 2, 2024.
DOI: https://doi.org/10.52337/pjia.v7i2.1056

[10] Y. Shao and Q. Yin, "A Review the Role of Artificial Intelligence in Media Content Creation for SDGs Development," *Journal of Lifestyle and SDGs Review*, vol. 5, no. 2, pp. e03971, 2025.
DOI: https://doi.org/10.47172/2965-730X.SDGsReview.v5.n02.pe03971

[11] N. Jain, "AI as a Catalyst for Educational Equity: Addressing Global Teacher Shortages and Learning Disparities," *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, vol. 11, no. 1, pp. 69-76, 2025.
DOI: https://doi.org/10.32628/cseit25111200

[12] M. Taşkın, "Artificial Intelligence in Personalized Education: Enhancing Learning Outcomes Through Adaptive Technologies and Data-Driven Insights," *Human Computer Interaction*, vol. 8, no. 1, pp. 173, 2025.
DOI: https://doi.org/10.62802/ygye0506

[13] D. Jiao, "AI-Driven Personalization in Higher Education: Enhancing Learning Outcomes through Adaptive Technologies," *Adult and Higher Education*, vol. 6, no. 6, 2024.
DOI: https://doi.org/10.23977/aduhe.2024.060607

[14] N.B. Trivedi, "AI in Education-A Transformative Force," *2023 1st DMIHER International Conference on Artificial Intelligence in Education and Industry 4.0 (IDICAIEI)*, pp. 1-4, 2023.
DOI: https://doi.org/10.1109/IDICAIEI58380.2023.10406541

[15] D. Aggarwal, "Exploring the Scope of Artificial Intelligence (AI) for Lifelong Education through Personalised & Adaptive Learning," *Journal of Artificial Intelligence, Machine Learning and Neural Network*, no. 41, pp. 21-26, 2023.
DOI: https://doi.org/10.55529/jaimlnn.41.21.26

[16] H.E. Sari, B. Tumanggor and D. Efron, "Improving Educational Outcomes Through Adaptive Learning Systems using AI," *International Transactions on Artificial Intelligence (ITALIC)*, vol. 3, no. 1, pp. 21-31, 2024.
DOI: https://doi.org/10.33050/italic.v3i1.647

[17] N.B. Trivedi, "AI in Education-A Transformative Force," *2023 1st DMIHER International Conference on Artificial Intelligence in Education and Industry 4.0 (IDICAIEI)*, pp. 1-4, 2023.
DOI: https://doi.org/10.1109/IDICAIEI58380.2023.10406541

[18] M. Asy'ari and S. Sharov, "Transforming Education with ChatGPT: Advancing Personalized Learning, Accessibility, and Ethical AI Integration," *International Journal of Essential Competencies in Education*, vol. 3, no. 2, pp. 119-157, 2024.
DOI: https://doi.org/10.36312/ijece.v3i2.2424

[19] W. Strielkowski, V. Grebennikova, A. Lisovskiy, G. Rakhimova and T. Vasileva, "AI-driven adaptive learning for sustainable educational transformation," *Sustainable Development*, vol. 33, no. 2, pp. 1921-1947, 2025.
DOI: https://doi.org/10.1002/sd.3221

[20] R. Ejjami, "The Adaptive Personalization Theory of Learning: Revolutionizing Education with AI," *Journal of Next-Generation Research 5.0*, 2024.
DOI: https://doi.org/10.70792/jngr5.0.v1i1.8

[21] S.I. Mohammad, N. Yogeesh, N. Raja, P. William, Ramesha, and A. Vasudevan,"Integrating AI and Fuzzy Systems to Enhance Education Equity," *Applied Mathematics & Information Sciences*, vol. 19, no. 2, pp. 403-422, 2025.
DOI: https://doi.org/10.18576/amis/190215

[22] A.P.N.A. Mote, "Role of AI in Personalized Education," *International Journal of Advanced Research in Science, Communication and Technology*, pp. 108-111, 2024.
DOI: https://doi.org/10.48175/ijarsct-15919

[23] E. Green, M. Bali, S. Bellomo, X. Bi, and R.M. Selvaratnam, "Navigating the future of higher education with AI : 2024 ICDE Leadership Summit policy dialogue report," *undefined*, 2024.
DOI: https://doi.org/10.58863/20.500.12424/4316083

[24] A. Dulundu, "AI in Education: Benefits and Concerns," *Next Generation Journal for The Young Researchers*, vol. 8, no. 1, pp. 81, 2024.
DOI: https://doi.org/10.62802/3fr4f412

[25] S. Ferebee, "AI and Accessibility: Breaking Barriers for People with Disabilities," *Premier Journal of Artificial Intelligence*, 2025.
DOI: https://doi.org/10.70389/PJAI.100012

[26] S. Mishra, "Transformative Impact of AI on Education: Personalizing Learning and Addressing Challenges," *International Journal for Research in Applied Science and Engineering Technology*, vol. 12, no. 8, pp. 1183-1189, 2024.
DOI: https://doi.org/10.22214/ijraset.2024.63891

[27] "VOSviewer - Visualizing scientific landscapes," VOSviewer. Accessed: Apr. 02, 2025. [Online]. Available: https://www.vosviewer.com//

[28] A. Greene, M. Baugh, C. Sherwood-Laughlin, L. Greathouse, J. Galyan, I.S. Stanojević, D. Sangmo, K. Jozkowski, M. Dubie and A. Chow, "Development of a sexual consent intervention for adolescents with intellectual and developmental disabilities," *Journal of Applied Research in Intellectual Disabilities*, vol. 37, no. 5, 2024.
DOI: https://doi.org/10.1111/jar.13272

[29] A.L. Dent and A.C. Koenka, "The Relation Between Self-Regulated Learning and Academic Achievement Across Childhood and Adolescence: A Meta-Analysis," *Educational Psychology Review*, vol. 28, no. 3, pp. 425-474, 2016.
DOI: https://doi.org/10.1007/s10648-015-9320-8

[30] E. Panadero, "A Review of Self-regulated Learning: Six Models and Four Directions for Research," *Frontiers in Psychology*, vol. 8, 2017.
DOI: https://doi.org/10.3389/fpsyg.2017.00422

[31] M. Bannert, *Metakognition beim lernen mit hypermedien*. Waxmann Verlag, 2007.
DOI: https://doi.org/10.1007/978-3-531-90704-8

[32] G. Siemens and K. Matheos, "Systemic Changes in Higher Education," *in education*, vol. 16, no. 1, 2012.
DOI: https://doi.org/10.37119/ojs2010.v16i1.42

[33] J. Kuzilek, M. Hlosta and Z. Zdrahal, "Open University Learning Analytics dataset," *Scientific Data*, vol. 4, no. 1, 2017.
DOI: https://doi.org/10.1038/sdata.2017.171

[34] Y. LeCun, Y. Bengio and G. Hinton, "Deep learning," *Nature*, vol. 521, no. 7553, pp. 436-444, 2015.
DOI: https://doi.org/10.1038/nature14539

[35] N.V. Chawla, K.W. Bowyer, L.O. Hall and W.P. Kegelmeyer, "SMOTE: Synthetic Minority Over-sampling Technique," *Journal of Artificial Intelligence Research*, vol. 16, pp. 321-357, 2002.
DOI: https://doi.org/10.1613/jair.953

[36] B. Grawemeyer, M. Mavrikis, W. Holmes, S. Gutiérrez-Santos, M. Wiedmann and N. Rummel, "Affective learning: improving engagement and enhancing learning with affect-aware feedback," *User Modeling and User-Adapted Interaction*, vol. 27, no. 1, pp. 119-158, 2017.
DOI: https://doi.org/10.1007/s11257-017-9188-z

[37] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77-101, 2006.
DOI: https://doi.org/10.1191/1478088706qp063oa

[38] L.J. Chen, "Critical components for inclusion of students with moderate intellectual disabilities into general junior high school," *International Journal of Developmental Disabilities*, vol. 63, no. 1, pp. 8-16, 2017.
DOI: https://doi.org/10.1080/20473869.2015.1108006

[39] J. Hattie and H. Timperley, "The Power of Feedback," *Review of Educational Research*, vol. 77, no. 1, pp. 81-112, 2007.
DOI: https://doi.org/10.3102/003465430298487

[40] L. Breiman, "Random Forests," *Machine Learning*, vol. 45, no. 1, pp. 5-32, 2001.
DOI: https://doi.org/10.1023/A:1010933404324

[41] A. Goodfellow, "Looking through the learning disability lens: inclusive education and the learning disability embodiment," *Children's Geographies*, vol. 10, no. 1, pp. 67-81, 2012.
DOI: https://doi.org/10.1080/14733285.2011.638179

[42] C. Romero and S. Ventura, "Educational Data Mining: A Review of the State of the Art," *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, vol. 40, no. 6, pp. 601-618, 2010.
DOI: https://doi.org/10.1109/TSMCC.2010.2053532

[43] R.S. Baker and P.S. Inventado,"Emergence and Innovation in Digital Learning: Foundations and Applications," *Emergence Innov. Digit. Learn. Found. Appl.*, pp. 83–98, 2016.
DOI: https://doi.org/10.15215/aupress/9781771991490.01

[44] D.M. Blei, A.Y. Ng and M.I. Jordan, "Latent Dirichlet Allocation," *Advances in Neural Information Processing Systems 14*, pp. 601-608, 2002.
DOI: https://doi.org/10.7551/mitpress/1120.003.0082

[45] M. Bienkowski, M. Feng, and B. Means, "Enhancing Teaching and Learning through Educational Data Mining and Learning Analytics: An Issue Brief.," *Off. Educ. Technol. US Dep. Educ.*, 2012, [Online]. Available: http://www.ed.gov/technology

[46] T. Elias, Learning Analytics: Definitions, Processes and Potential. 2011.

[47] D. Clow, "An overview of learning analytics," *Teaching in Higher Education*, vol. 18, no. 6, pp. 683-695, 2013.
DOI: https://doi.org/10.1080/13562517.2013.827653

[48] K.E. Arnold and M.D. Pistilli, "Course signals at Purdue," *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge*, pp. 267-270, 2012.
DOI: https://doi.org/10.1145/2330601.2330666

[49] R. Al-Shabandar, A. Hussain, A. Laws, R. Keight, J. Lunn and N. Radi, "Machine learning approaches to predict learning outcomes in Massive open online courses," *2017 International Joint Conference on Neural Networks (IJCNN)*, pp. 713-720, 2017.
DOI: https://doi.org/10.1109/IJCNN.2017.7965922

[50] S. Palmer, "Modelling engineering student academic performance using academic analytics," 2013.
http://www.ijee.ie/latestissues/Vol29-1/13_ijee2682ns.pdf

[51] O. Viberg, M. Hatakka, O. Bälter and A. Mavroudi, "The current landscape of learning analytics in higher education," *Computers in Human Behavior*, vol. 89, pp. 98-110, 2018.
DOI: https://doi.org/10.1016/j.chb.2018.07.027

[52] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77-101, 2006.
DOI: https://doi.org/10.1191/1478088706qp063oa

[53] J. Maldonado-Mahauad, M. Pérez-Sanagustín, R.F. Kizilcec, N. Morales and J. Munoz-Gama, "Mining theory-based patterns from Big data: Identifying self-regulated learning strategies in Massive Open Online Courses," *Computers in Human Behavior*, vol. 80, pp. 179-196, 2018.
DOI: https://doi.org/10.1016/j.chb.2017.11.011

[54] L. Haiyang, Z. Wang, P. Benachour and P. Tubman, "A Time Series Classification Method for Behaviour-Based Dropout Prediction," *2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT)*, 2018.
DOI: https://doi.org/10.1109/ICALT.2018.00052

[55] P.H. Jacques, H.K. Moss and J. Garger, "A Synthesis of AI in Higher Education: Shaping the Future," *Journal of Behavioral and Applied Management*, vol. 24, no. 2, 2024.
DOI: https://doi.org/10.21818/001c.122146

[56] B. Wang, S.H. Ramli, S. Roslan, A.R.A. Rahman and Z. Li, "A review on application of mobile media in personalized special education," *Environment and Social Psychology*, vol. 9, no. 8, 2024.
DOI: https://doi.org/10.59429/esp.v9i8.2910

[57] R. Bhatnagar, "Using AI to Create More Equitable and Inclusive Higher Education Learning Systems," *Communications on Applied Nonlinear Analysis*, vol. 32, no. 3s, pp. 25-44, 2024.
DOI: https://doi.org/10.52783/cana.v32.2531

[58] A. Swindell, L. Greeley, A. Farag and B. Verdone, "Against Artificial Education: Towards an Ethical Framework for Generative Artificial Intelligence (AI) Use in Education," *Online Learning*, vol. 28, no. 2, 2024.
DOI: https://doi.org/10.24059/olj.v28i2.4438

[59] O. Boateng and.B. Boateng, "Algorithmic bias in educational systems: Examining the impact of AI-driven decision making in modern education," *World Journal of Advanced Research and Reviews*, vol. 25, no. 1, pp. 2012-2017, 2025.
DOI: https://doi.org/10.30574/wjarr.2025.25.1.0253

[60] D. Liu, "The Impact and Prospects of AI-Generated Content in Educational Environments," *Transactions on Computer Science and Intelligent Systems Research*, vol. 6, pp. 64-71, 2024.
DOI: https://doi.org/10.62051/7mewnb62

[61] A.A. Funa and R.A.E. Gabay, "Policy guidelines and recommendations on AI use in teaching and learning: A meta-synthesis study," *Social Sciences & Humanities Open*, vol. 11, pp. 101221, 2025.
DOI: https://doi.org/10.1016/j.ssaho.2024.101221

[62] C. Zhang, "AI in Education: Opportunities, Challenges, and Pathways for Equitable Learning," *Journal of Education, Humanities and Social Sciences*, vol. 45, pp. 723-728, 2024.
DOI: https://doi.org/10.54097/kfgp6j07

[63] D. Aggarwal, "Exploring the Scope of Artificial Intelligence (AI) for Lifelong Education through Personalised & Adaptive Learning," *Journal of Artificial Intelligence, Machine Learning and Neural Network*, no. 41, pp. 21-26, 2023.
DOI: https://doi.org/10.55529/jaimlnn.41.21.26

[64] X. Xu, "Zero-knowledge proofs in education: a pathway to disability inclusion and equitable learning opportunities," *Smart Learning Environments*, vol. 11, no. 1, 2024.
DOI: https://doi.org/10.1186/s40561-024-00294-w

[65] A. Faccia, M. Ridon, Z. Beebeejaun and N.M.R. Mosteanu, "Advancements and Challenges of Generative AI in Higher Educational Content Creation A Technical Perspective," *2023 8th International Conference on Information Systems Engineering*, pp. 48-54, 2023.
DOI: https://doi.org/10.1145/3641032.3641055

[66] S. Elbourn, "The Impact of Generative AI on Student Churn and the Future of Formal Education," 2024, *arXiv*. doi: Formal Education", *arXiv*. 2024
DOI: https://doi.org/10.48550/ARXIV.2412.00605

[67] K. KJ, "A SURVEY ON AI-CONTENT GENERATOR," *INTERANTIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT*, vol. 09, no. 01, pp. 1-9, 2025.
DOI: https://doi.org/10.55041/IJSREM41078

[68] B. Singh and D.A.K. Pathania, "AI-Driven Content Creation and Curation in Digital Marketing Education: Tools and Techniques," *International Journal of Engineering Science and Humanities*, vol. 14, no. Special Issue 1, pp. 14-26, 2024.
DOI: https://doi.org/10.62904/8fbh3144

[69] S.S. Reddy, G. N, A.K. B, J. S, M.D. R and N. C, "AI-Driven Personalized Learning and Content Extraction: An Emerging Paradigm," *Journal of Information Security System and Cyber Criminology Research*, vol. 1, no. 3, pp. 32-39, 2025.
DOI: https://doi.org/10.46610/JoISSCCR.2024.v01i03.004

[70] K. Zhang and A.B. Aslan, "AI technologies for education: Recent research & future directions," *Computers and Education: Artificial Intelligence*, vol. 2, pp. 100025, 2021.
DOI: https://doi.org/10.1016/j.caeai.2021.100025

[71] Z. Aalam, S. Aziz, K.L. Lew and C.S. Lee, "Real-Time Emotion Detection Using Artificial Intelligence: A Review," *International Journal on Robotics, Automation and Sciences*, vol. 7, no. 1, pp. 104-110, 2025.
DOI: https://doi.org/10.33093/ijoras.2025.7.1.12

[72] A.D.A. Hauna, A.P. Yunus, M. Fukui and S. Khomsah, "Enhancing LLM Efficiency: A Literature Review of Emerging Prompt Optimization Strategies," *International Journal on Robotics, Automation and Sciences*, vol. 7, no. 1, pp. 72-83, 2025.
DOI: https://doi.org/10.33093/ijoras.2025.7.1.9