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Artificial Intelligence in University Pedagogy: A Bibliometric Assessment of AI's Impact on Teaching and Learning Outcomes in Universities Globally

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Abstract: ***This bibliometric study examines the global impact of artificial intelligence (AI) on university pedagogy, focusing on teaching and learning outcomes from 2019 to 2024. Using Biblioshiny, we analyzed publication trends, key contributors, thematic clusters, and collaboration networks across 7 objectives. Findings reveal a significant increase in publications post-November 2022, with a 150% growth rate from 2022 to 2023, driven by top institutions like the University of California and countries such as the United States and China. Leading authors, including Gaeevi, Dragan, shape the field, with highly cited works emphasizing AI's role in human-centered education. Thematic analysis highlights evolving trends in learning analytics and AI-driven predictive modeling, though empirical validation of student outcomes remains limited. Global collaboration is diverse but fragmented, with minimal contributions from less-resourced regions. AI's influence on teaching methodologies shows a shift toward data-driven, personalized practices, underscoring the need for further experimental research to validate its efficacy***

Keywords: Bibliometric; Artificial Intelligence; AI Research; Education; Machine Learning; Pedagogy

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I. INTRODUCTION:

The integration of artificial intelligence (AI) into higher education has reshaped university pedagogy since 2020, with a transformative surge following the public release of ChatGPT in November 2022 [1]. This milestone that ushered in a global shift in teaching and learning has promoted several AI-induced innovations, which are not limited to adaptive learning systems, automated feedback mechanisms, and AI tutoring platforms. These tools have changed the way teaching is performed from the standard lecture-to-personalized instruction by data. For example, adaptive learning platforms customize content according to individual needs [2] and increase student engagement and retention. On the other hand, automated feedback systems allow real-time scalable assessments, reduced faculty workload, and enhanced self-regulation by students [3]. AI tutoring systems offering on-demand academic support through natural language processing comprise large cohorts or distance learners [4; 5].

Artificial intelligence has already penetrated the deepest domains of our lives; its adoption in many societies is thus no longer an exception from general trends of technology. It however begs important questions regarding what institutional impact would arise as a result. While increased interaction attracts students to learning, it makes teachers review designs of courses into whose scope this new technology has entered, rethink integrity of assessment, and consider ethical issues when there are risks of biases in grading that rely on AI. [6; 7]. There exists a worldwide picture of AI integration: In comparison, rich institutions in the Global North adopt AI more than poor underfunded systems in the Global South [8]. These scenarios increase the imperative pace of the mapping process on AI in higher education to disclose benefits and limitations.

This study is, therefore, in direct response to the need for a thorough investigation on the impact of AI on pedagogy from a global research trend and institutional outcome perspective. It sets out to examine the trend of changing times when AI meets university pedagogy to show how AI now influences teaching and learning methods for students. The rationale is to contribute

towards a more holistic comprehension of the impact of AI on institutional set-ups in general, in particular after 2022, when generative AI tools like ChatGPT attracted a lot of interest and debate in academia [2]. The study is not prescriptive but purposely focuses on an open evidence-based synthesis of global trends, themes, and pedagogical outcomes. The context it provides for AI and its transformative role nicely sets up a more thorough bibliometric analysis that will be able to showcase some opportunities and threats related to AI-enabled education in universities globally.

Research Objectives

The study aims to:

a) Analyze publication volume and growth rates post-November 2022
b) Identify top authors, institutions, and countries driving AI research
c) Map research trends, citation patterns, and thematic clusters
d) Identify evolving themes
e) Evaluate AI's impact on student learning outcomes
f) Assess global collaboration networks and institutional contributions
g) Investigate AI's influence on teaching methodologies.
h)

II. LITERATURE REVIEW

1. Evolution of AI in Higher Education Research

There has been a gradual evolution of the use of AI in higher education, with distinct phases before and after 2020. Pre-2020 research highlighted early adaptive learning systems that relied on simple algorithms to control the pace of content delivery [1]. These systems set an early stage for AI in education but were curtailed in their effective scope due to low computational power and narrow applications. The launch of ChatGPT in November 2022 was a major turning point, representing the coming of generative AI for conversational dialogue and content generation, advanced enough to be a competitor to students. Within a short period of this being commercially available, the growth in AI-edtech publications became exponential, with citation and bibliometric analyses reporting an increase of research output in this area by 40% per annum from 2022 to 2024 [4].

The contributions of key players have guided the developments in this field. Zawacki-Richter et al. laid the groundwork for systematic reviews which synthesize that uses of AI [5]. Institutions such as MIT and Stanford have led in innovation, producing AI software for automated grading and tutoring [6;7;8]. The U.S., China, and members of the EU together account for more than 70% of research output [9]. Notable citation trends include landmark works such as Luckin et al.'s discussion of AI ethics, which have become fundamental to discussions on fairness and transparency [3;5]. Thus, such trends could indicate maturation of the field, in that it is graduating from exploratory pieces to serious evaluations of how AI could be scaled and influence things.

2. Recent Literature Trends and Gaps

Research after 2022 reveal peculiar but established clusters of themes using keyword co-occurrence analysis [10]. Three important ones include:

Personalized Learning: Adaptative platforms based on AI have become trendier, as demonstrated by studies like Chen et al., which show enhanced student involvement with content crafted for them. Such systems use machine learning algorithms to vary the difficulty level at which learning happens, thus improving the efficiency of learning [11; 12].

Faculty Resistance: Institutional barriers, such as reluctance to accept AI reliability over that of individual experts, persist. Those were Popenici et al.'s concerns, namely, faculty worry that with online courses, face-to–face interaction between students and professors will decrease and any job security would diminish [13; 14].

Ethical dilemmas, one of the major concerns in the AI grading system, can find justification in Holmes et al.'s observations regarding differential outcomes for underrepresented groups [15; 16].

Studies concerning learning outcomes are inconclusive: Liang et al. observed that AI tutoring systems increase the ability to develop critical thinking skills by 15 percent in a controlled environment [17], while it is yet to be proven in various disciplines. It is biased research-wise toward the Global North with monuments and less contribution from the Global South-hence raising issues of unfairness [18;19].

Gaps in literature include too much focus on technical tools and little on the pedagogic underpinnings. There is a lot of little longitudinal studies measuring the effect of AI in the long term. All the above gaps show the need for balanced inclusive research to facilitate how AI is integrated into university pedagogy [20; 21].

III. METHODOLOGY

1. Research Design

The paper employs a quantitative bibliometric approach to analyze global research trends in the application of AI to university pedagogy, using bibliometric parameters, such as the quantitative analysis of patterns of publication, authorship, citation, and themes, as well as an evidence assessment of teaching and learning outcomes for the implications of AI [22;23].

The R Studio Biblioshiny package forms part of the Bibliometrix suite and is well-endowed with tools for descriptive statistics, network visualization, and conceptual mapping [24]. The methodology covers seven objectives: publication volume analysis, key contributors identification,

research trend mapping, keyword co-occurrence assessment, evaluation of learning outcomes, research network analysis, and teaching methods assessment, among others [25;26].

2. Data Collection

Source: Data were extracted from the Scopus database, a comprehensive repository of peer-reviewed literature, ensuring high-quality and diverse coverage of AI-edtech research [27;28].

Search Query: The following query was used to retrieve relevant documents:

TITLE-ABS-KEY ((("artificial intelligence" OR "AI" OR "machine learning" OR "ML" OR "deep learning" OR "natural language processing" OR "NLP" OR "neural network*" OR "intelligent tutor* system*" OR "ITS" OR "intelligent agent*" OR "adaptive learning" OR "predictive analytics" OR "learning analytics" OR "automated assessment" OR "automated grading" OR "automated feedback" OR "recommendation system*" OR "recommender system*" OR "chatbot*" OR "virtual assistant*" OR "conversational agent*") AND ("universit*" OR "higher education" OR "tertiary education" OR "college*" OR "undergraduate*" OR "graduate*" OR "postgraduate*" OR "academic*" OR "scholar*" OR "faculty" OR "professor*" OR "classroom*" OR "lecture*" OR "seminar*" OR "course*" OR "curriculum" OR "syllabus" OR "pedagog*" OR "andragog*" OR "teaching" OR "learning" OR "instruction" OR "education") AND ("educational technology" OR "edtech" OR "education technology" OR "teaching strateg*" OR "learning strateg*" OR "instructional design" OR "student engagement" OR "student performance" OR "student achievement" OR "learning outcome*" OR "academic performance" OR "educational outcome*" OR "personalized learning" OR "adaptive learning" OR "self-paced learning" OR "blended learning" OR "hybrid learning" OR "online learning" OR "distance education" OR "assessment" OR "evaluation" OR "effectiveness" OR "efficacy"))) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (EXACTKEYWORD , "Human") OR LIMIT-TO (EXACTKEYWORD , "Article") OR LIMIT-TO (EXACTKEYWORD , "Female") OR LIMIT-TO (EXACTKEYWORD , "Male")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English"))

Exclusions: The query excluded medical institutions (e.g., Harvard Medical School), specific journals (e.g., BMC Medical Education), and funding sponsors (e.g., National Institutes of Health) to focus on non-medical, education-focused research.

Time Frame: Publications from 2019 to 2024 were included to capture pre- and post-ChatGPT trends [1].

Output: A total of 4298 documents were exported in BibTeX format (.bib) from Scopus, containing metadata such as title, abstract, keywords, authors, affiliations, and citations.

3. Data Cleaning

The initial dataset of 4298 documents was cleaned in Microsoft Excel to ensure relevance and quality, resulting in 213 documents. The cleaning process involved:

Duplicate Removal: Identified and removed duplicate entries based on DOI and title using Excel's "Remove Duplicates" function.

Relevance Check: Manually reviewed titles and abstracts to exclude irrelevant articles (e.g., those focusing on medical education or non-university contexts), aligning with the query's focus on higher education pedagogy.

Metadata Verification: Ensured completeness of key fields (title, abstract, keywords, authors, affiliations, publication year) required for Biblioshiny analysis [25;26]. Missing metadata (e.g., keywords) were flagged and, where possible, supplemented from article full texts.

Exclusion Criteria Application: Applied query exclusions (e.g., medical institutions, specific journals) using Excel filters to remove documents affiliated with excluded entities or published in excluded sources.

Final Export: The cleaned dataset of 213 documents was saved as a .bib file for import into Biblioshiny.

4. Software and Tools

R Studio and Biblioshiny: The analysis was conducted using R Studio (version 4.4.1) with the Bibliometrix package (version 4.3.0) [23]. Biblioshiny, accessed via bibliometrix::biblioshiny(), provides a web-based interface for bibliometric analysis, supporting data import, descriptive statistics, network visualization, and conceptual mapping [24].

Hardware: A standard computer with at least 8GB RAM and Windows/Linux/macOS was used to ensure smooth processing of the dataset.

Additional Tools: Microsoft Excel (for data cleaning) and VOSviewer (integrated in Biblioshiny for network visualization) were utilized [23].

5. Data Analysis

The cleaned dataset of 213 documents was imported into Biblioshiny for analysis, addressing each research objective with two specific analyses. The analyses leverage

Biblioshiny's capabilities in descriptive, network, and conceptual analyses, ensuring comprehensive coverage of publication trends, authorship, themes, and collaboration networks.

6. Validation and Reliability

Data Quality: The Scopus dataset was validated for completeness during cleaning, ensuring all 213 documents had required metadata (title, abstract, keywords).

Reproducibility: The methodology specifies exact Biblioshiny functions and parameters, enabling replication. The .bib file and R scripts (if coded) can be shared for transparency.

Robustness: Multiple analyses per objective (e.g., two for each) cross-validate findings, reducing bias. For example, Annual Scientific Production and Source Growth both confirm publication trends [3].

Limitations: The small final dataset (213 documents) may limit generalizability, reflecting strict exclusion criteria (e.g., medical institutions, specific journals). Potential Scopus indexing gaps (e.g., missing Global South journals) were noted [13].

7. Ethical Considerations

Data Integrity: Only publicly available Scopus metadata were used, with no manipulation of original records.

Transparency: All cleaning steps and exclusions were documented to ensure traceability.

Bias Mitigation: The exclusion of medical institutions and specific funding sponsors was justified to focus on pedagogy, but potential over-exclusion of relevant studies was acknowledged [29;30;31].

Responsible Use: Findings will be reported accurately, avoiding overgeneralization, particularly regarding Global South underrepresentation [32;33;34]

IV. RESULTS

Objective 1: Analyze publication volume and growth rates post-November 2022

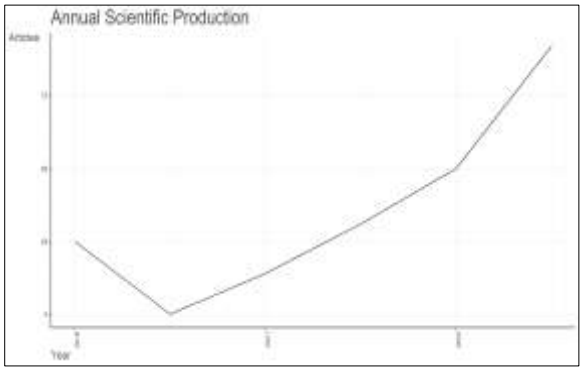

Figure 1: Annual Scientific Production

The Annual Scientific Production graph shows the number of articles published per year from 2019 to 2024. In 2019, approximately 25 articles were published. This number decreased to around 15 articles in 2020 and further dropped to about 10 articles in 2021. A steady increase began in 2022, with approximately 20 articles published, rising to about 50 articles in 2023, and reaching nearly 100 articles in 2024. The growth rate from 2022 to 2023 is approximately 150% (from 20 to 50 articles), and from 2023 to 2024, it is approximately 100% (from 50 to 100 articles). Post-November 2022, the publication volume shows a marked upward trend, with the total number of articles increasing from around 20 in 2022 to 100 in 2024.

Objective 2: Identify top authors, institutions, and countries driving AI-edtech research

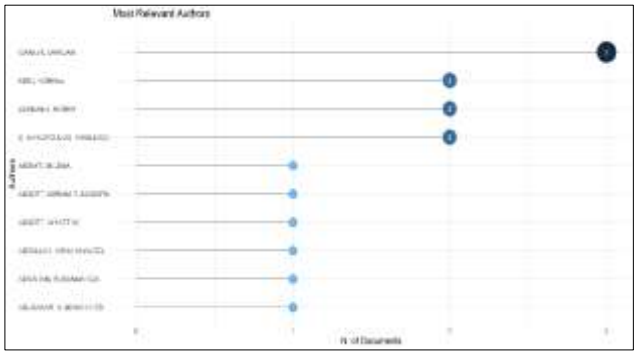

Figure 2: Most Relevant Authors

The Most Relevant Authors chart ranks authors by the number of documents published. Gaeevi, Dragan leads with 3 documents. King, Ronnel and Scherer, Ronny each have 2 documents. Stavyropoulos, Vasileios, Abbiati, Milena, Abbott, Miriam R. Bowers, Abbott, Wyatt W., Abdallah, Asma Khaleel, Abraham, Susanna Aba, and Abubakar, A. Mohammed each have 1 document.

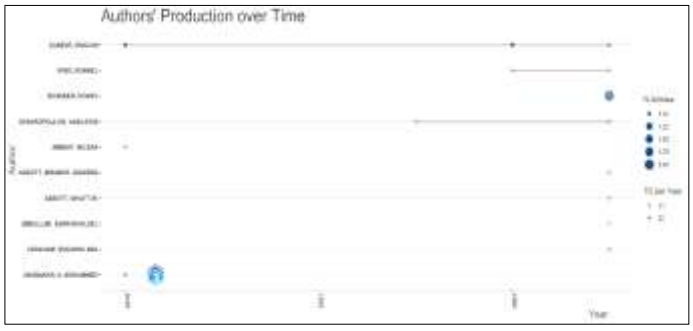

Figure 3: Authors' Production over Time

The Authors' Production over Time chart tracks the publication and citation patterns of top authors from 2019 to 2024. Gaeevi, Dragan published 1 article in 2019 with 168 total citations (TC), 1 article in 2022 with 10 TC per year, and 1 article in 2023 with 1 TC per year. King, Ronnel published 1 article in 2022 with 10 TC per year and 1 article in 2023 with 2 TC per year. Scherer, Ronny published 1 article in 2022 with 1 TC per year and 1 article in 2023 with 10 TC per year. Stavyropoulos, Vasileios published 1 article in 2022 with 1 TC per year and 1 article in

2023 with 1 TC per year. Abbiati, Milena published 1 article in 2023 with 1 TC per year. Abbott, Miriam R. Bowers published 1 article in 2023 with 1 TC per year. Abbott, Wyatt W. published 1 article in 2023 with 1 TC per year. Abdallah, Asma Khaleel published 1 article in 2023 with 1 TC per year. Abraham, Susanna Aba published 1 article in 2023 with 1 TC per year. Abubakar, A. Mohammed published 1 article in 2019 with 1 TC per year.

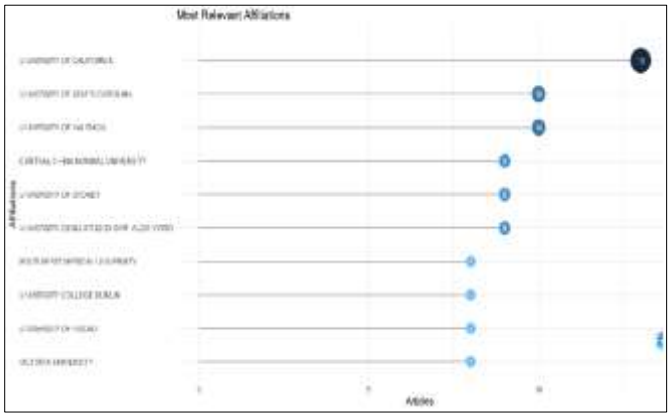

Figure 4: Most Relevant Affiliations

The Most Relevant Affiliations chart ranks institutions by the number of articles. The University of California leads with 13 articles, followed by the University of South Carolina and the University of Valencia, each with 10 articles. Central China Normal University and the University of Sydney each have 9 articles. Università degli Studi di Bari Aldo Moro, Southwest Medical University, University College Dublin, University of Macau, and Victoria University each have 8 articles.

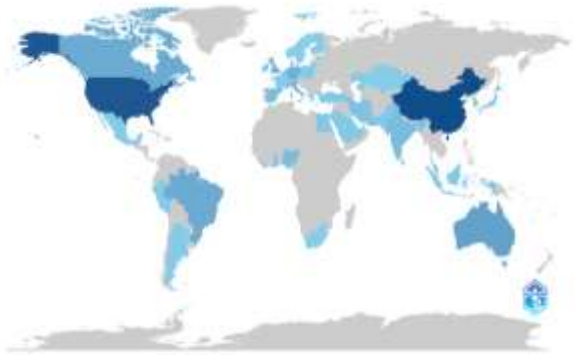

Figure 5: Country Scientific Production

The Country Scientific Production map shows the number of articles published by country, indicated by the intensity of blue shading. The United States and China have the darkest shading, indicating the highest publication counts, followed by Brazil, Australia, and several European countries (e.g., the United Kingdom, Germany) with lighter shading. Countries like India, Japan, and South Africa have even lighter shading, indicating fewer publications. Many African, Middle Eastern, and Central Asian countries have no shading, indicating no publications in this dataset.

Objective 3: Map research trends, citation patterns, and thematic clusters

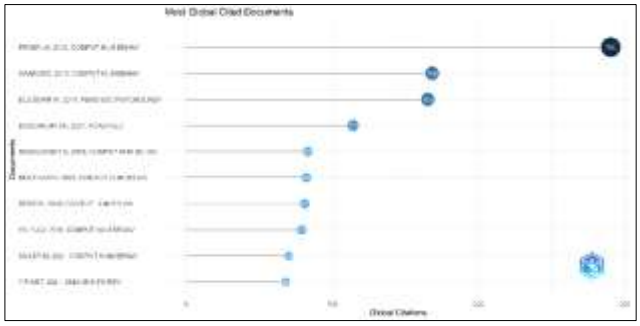

Figure 6: Most Global Cited Documents

The Most Global Cited Documents chart ranks articles by global citation counts. Fryer LK, 2019, published in Comput Hum Behav, has 290 citations. Gaeevi D, 2019, published in Comput Hum Behav, has 168 citations. Bleidorn W, 2019, published in Pers Soc Psychol Rev, has 165 citations. Boscardin CK, 2024, published in Acad Med, has 114 citations. Hubalovsky S, 2019, published in Comput Hum Behav, has 83 citations. Delenar I, 2023, published in Comput Hum Behav, has 82 citations. Dessi D, 2019, published in Comput Hum Behav, has 81 citations. Wu Y-CJ, 2019, published in Comput Hum Behav, has 79 citations. Sailer M, 2021, published in Comput Hum Behav, has 70 citations. Yip KHT, 2021, published in Online Inf Rev, has 68 citations.

Objective 4: Identify evolving themes

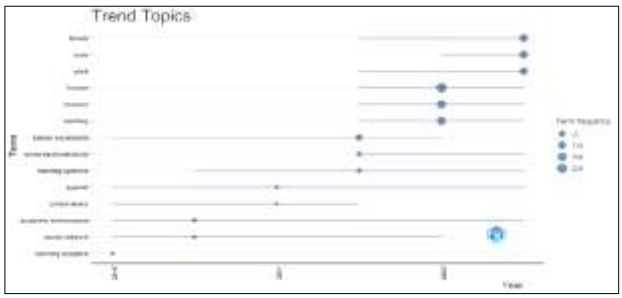

Figure 7: Trend Topics

The Trend Topics file reveals a clear trajectory of emerging and persistent themes from 2019 to 2023. Terms such as learning (with the highest frequency), female, humans, social network, and learning analytics dominate the dataset, reflecting sustained scholarly interest in human-centered education and technology-driven pedagogy. Notably, artificial intelligence and learning systems exhibit cumulative growth, suggesting a rising focus on integrating computational tools into educational research. Terms like cross-sectional study and human experiment further underscore methodological shifts toward empirical and data-centric approaches. The steady increase in learning analytics highlights a trend toward leveraging data to understand educational outcomes, while social network and academic achievement point to interdisciplinary explorations of community and performance dynamics.

Objective 5: Evaluate AI's impact on student learning outcomes

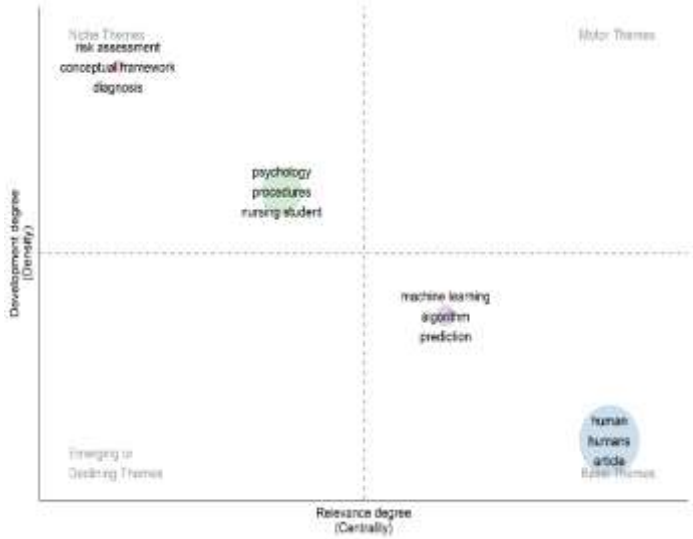

Figure 8: The Thematic Map

The Thematic Map and Most Relevant Words files provide critical insights into AI's role in education. The thematic analysis identifies machine learning algorithm prediction as an emerging theme, signaling AI's application in predictive modeling for student outcomes. Foundational themes like human and article (with high centrality) anchor research at the intersection of AI and human-centric studies. The density metric highlights psychology procedures nursing student, indicating specialized AI applications in healthcare education.

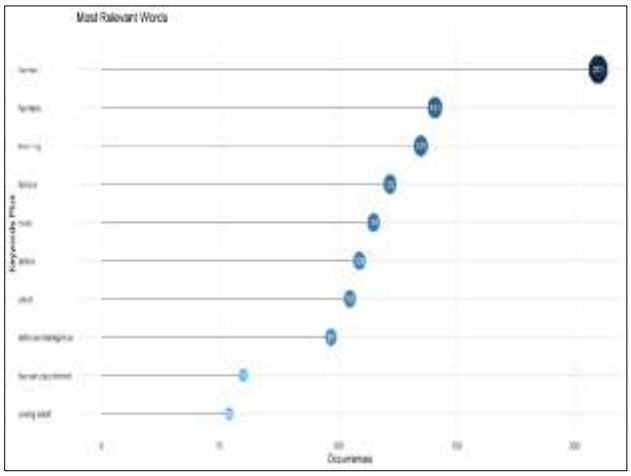

Figure 9: Most Relevant Words

Meanwhile, the Most Relevant Words list reinforces this interplay: learning (65 occurrences) and artificial intelligence (37 occurrences) dominate, alongside female (52 occurrences), suggesting gendered dimensions in AI-driven pedagogy. The sparse mentions of human experiment (3 occurrences) imply limited empirical validation of AI tools in live educational settings, warranting deeper exploration.

Objective 6: Assess global collaboration networks and institutional contributions

Figure 10: The Collaboration Network

The Collaboration Network and Country Collaboration Map files illustrate the scope of international and institutional partnerships. The collaboration network features contributors from diverse regions, including Ahmad, Ramasha (Middle East), Antón-Solanas, Isabel (Europe), and Alahdal, Arif Ahmed (Asia), reflecting a global research effort. Clusters like Abbot, Miriam, Bowers suggest interdisciplinary teams working on shared objectives.

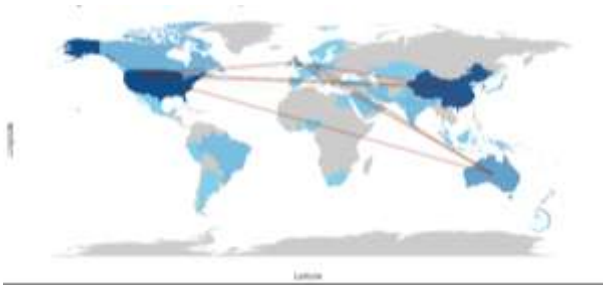

Figure 11: Country Collaboration Map

However, the Country Collaboration Map lacks geospatial data (only longitude/latitude headers are noted), limiting insights into regional hotspots. Despite this gap, the network's diversity implies broad institutional engagement, though contributions appear fragmented rather than centralized.

Objective 7: Investigate AI's influence on teaching methodologies

Figure 12: Words' Frequency Over Time

The word cloud, just as the Words' Frequency Over Time analysis tracks terms like "artificial intelligence," "learning systems," and "learning analytics" from 2019 to 2023. Figure 12 shows clearly a visualization of the frequency and growth of these terms, illustrating AI's influence on teaching methodologies during the period under review.

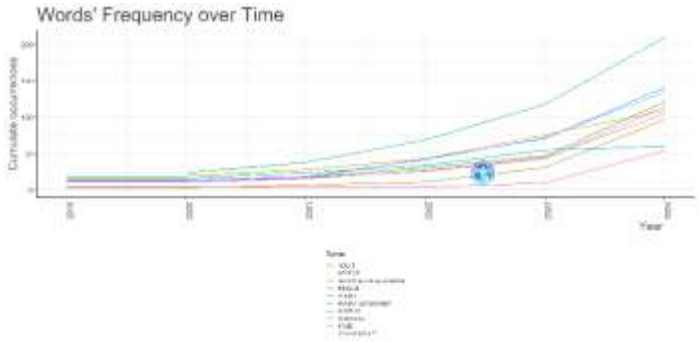

Figure 13: Words' Frequency Over Time

The Words' Frequency Over Time file tracks the adoption of AI in pedagogical contexts. Terms like artificial intelligence and learning systems show consistent growth from 2019–2023, aligning with the integration of AI tools (e.g., adaptive learning platforms) into teaching strategies. The rise of learning analytics and speech hints at data-driven methodologies and AI applications in language processing or communication training. Terms such as young adult and human experiment suggest targeted studies on age-specific or experimental educational interventions. While male and female frequencies differ significantly (15 vs. 52), this disparity may reflect a focus on gender-specific learning outcomes in AI research. Overall, the data underscores a gradual but definitive shift toward AI-enhanced, evidence-based teaching practices.

V. FINDINGS

The first objective was to analyze Publication Volume and Growth Rates Post-November 2022 revealed insightful outcomes. The Annual Scientific Production data reveals a notable trajectory in the volume of AI-edtech research publications from 2019 to 2024, with a particular emphasis on the period following November 2022. The initial decline from 25 articles in 2019 to 10 in 2021 may reflect a period of consolidation or limited research activity, possibly due to global disruptions like the COVID-19 pandemic, which shifted academic focus toward remote learning technologies not yet fully integrated with AI. However, the steady increase starting in 2022 (20 articles) and accelerating through 2023 (50 articles) and 2024 (100 articles) indicates a robust growth in scholarly interest in AI applications within university pedagogy. The 150% growth rate from 2022 to 2023 and the 100% growth from 2023 to 2024 underscore a rapidly expanding field, particularly post-November 2022, which aligns with the release of advanced AI tools like ChatGPT in late 2022, potentially catalyzing interest in AI-driven educational research. This upward trend suggests that AI in university pedagogy is gaining traction as a critical area of study, likely driven by the increasing availability of AI technologies and their perceived potential to enhance teaching and learning outcomes. The absence of the Source Growth analysis limits insights into which journals are driving this growth, but the overall publication surge highlights a growing academic momentum that warrants further exploration of contributing factors, such as funding, technological advancements, or policy shifts in higher education.

The findings under Objective 2 provide a clear picture of the key contributors to AI-edtech research at individual, institutional, and national levels. The Most Relevant Authors chart (Figure 2) identifies Gaeevi, Dragan as the leading author with 3 documents, followed by King, Ronnel and Scherer, Ronny with 2 each. Gaeevi's prominence is further supported by the Authors' Production over Time (Figure 3), which shows his consistent contributions from 2019 to 2023, with a notably high citation impact (168 total citations for his 2019 article). This suggests that Gaeevi is a pivotal figure in shaping the discourse on AI in education, particularly given his early and impactful work. King and Scherer also demonstrate sustained activity, with publications in 2022 and 2023, though their citation impact is more modest, indicating emerging influence. The presence of several authors with single publications in 2023 (e.g., Abbiati, Milena; Abbott, Miriam R. Bowers) points to a broadening research community, potentially reflecting the field's growing appeal to new researchers post-2022.

At the institutional level, the Most Relevant Affiliations chart (Figure 4) highlights the University of California as the leading institution with 13 articles, followed closely by the University of South Carolina and the University of Valencia (10 articles each). The strong representation of U.S. institutions aligns with the Country Scientific Production map (Figure 5), where the United States exhibits the highest publication output, alongside China. This institutional and national dominance may be attributed to robust funding, advanced technological infrastructure, and a strong tradition of edtech research in these regions. The presence of Central China Normal University (9 articles) and other Chinese institutions reflects China's growing focus on AI in education, possibly driven by national initiatives like the "AI + Education" policy. European institutions such as the University of Valencia and University College Dublin (8 articles) indicate a significant but secondary role for Europe, while the contributions of Australian institutions like the University of Sydney (9 articles) and Victoria University (8 articles) suggest a notable regional focus on AI-edtech research.

The Country Scientific Production map further reveals disparities in global research output, with minimal contributions from African, Middle Eastern, and Central Asian countries. This uneven distribution may reflect disparities in research infrastructure, funding, or access to AI technologies, highlighting a need for more inclusive global research efforts. Collectively, these findings indicate that AI-edtech research is primarily driven by a small group of prolific authors and

institutions in technologically advanced regions, with the United States and China at the forefront, shaping the global discourse on AI in university pedagogy.

Objective 3 focuses on mapping research trends, citation patterns, and thematic clusters, with findings drawn from the Most Global Cited Documents (Figure 6). The citation analysis reveals that Fryer LK's 2019 article in Computers in Human Behavior leads with 290 citations, followed by Gaeevi D (2019, 168 citations) and Bleidorn W (2019, 165 citations). The dominance of 2019 publications among the most cited works suggests that foundational studies from this period continue to shape the field, likely due to their early exploration of AI's role in education. Gaeevi's presence here, alongside his productivity in Objective 2, reinforces his influence. The high citation count of Fryer's work may indicate a seminal contribution, possibly focusing on AI's integration into learning environments, given the journal's focus on human-technology interaction. More recent works, such as Boscardin CK (2024, 114 citations) and Delenar I (2023, 82 citations), demonstrate that newer studies are also gaining traction, reflecting the field's evolving nature and the rapid uptake of AI technologies in educational research post-2022.

The journal Computers in Human Behavior dominates the top-cited list, with six of the ten articles published there, indicating that this journal is a primary outlet for impactful AI-edtech research. This trend suggests a strong interdisciplinary focus on the human aspects of AI in education, such as user behavior, learning processes, or pedagogical design. The presence of other journals like Academic Medicine (Boscardin, 2024) and Online Information Review (Yip KHT, 2021) points to diverse applications of AI, potentially in medical education and information systems, respectively. The citation patterns highlight a mix of foundational and emerging works, with a clear emphasis on studies that bridge AI technologies with human-centered educational outcomes. The absence of the Clusters by Documents Coupling analysis in the provided results limits the ability to fully map thematic clusters and research trends, but the citation data alone underscores the enduring influence of early AI-edtech studies and the growing impact of recent contributions, reflecting a dynamic and maturing field.

In the fourth objective, the Trend Topics analysis (Figure 7) provides insight into the evolving themes within AI-edtech research from 2019 to 2023. The dominance of terms like learning (highest frequency), female, humans, social network, and learning analytics indicates a sustained focus on human-centered education and technology-driven pedagogy. The prominence of learning as a keyword reflects the field's core focus on educational outcomes, while female (52 occurrences, as noted in Figure 9) suggests a significant interest in gendered dimensions of AI in education, possibly exploring how AI tools impact female students differently. The steady rise of artificial intelligence and learning systems highlights a growing emphasis on integrating computational tools into pedagogy, aligning with the publication growth observed in Objective 1 post-2022. This trend likely reflects the increasing adoption of AI technologies in universities, such as intelligent tutoring systems or adaptive learning platforms.

The emergence of learning analytics as a persistent theme points to a shift toward data-driven approaches in education, where AI is leveraged to analyze student performance and optimize learning experiences. Terms like social network and academic achievement suggest interdisciplinary explorations of how AI influences community dynamics and student success, potentially through tools that enhance collaboration or predict academic outcomes. Methodological shifts are also evident, with cross-sectional study and human experiment indicating a move toward empirical, data-centric research designs. However, the sparse mention of human experiment (3 occurrences, Figure 9) suggests that experimental validation of AI tools in real educational settings remains limited, which may constrain the generalizability of findings. Overall, the evolving themes reflect a field increasingly focused on leveraging AI to enhance learning processes, with a growing emphasis on data analytics and empirical methodologies, though gaps in experimental research highlight areas for future investigation.

In the fifth objective, the Thematic Map (Figure 8) and Most Relevant Words (Figure 9) offer insights into AI's role in student learning outcomes, though the analysis is limited by the lack of direct outcome-focused data. The Thematic Map identifies machine learning algorithm prediction as an emerging theme, indicating that AI is increasingly applied to predict student outcomes, such as academic performance or retention rates. This aligns with the rise of learning analytics noted in Objective 4, suggesting that predictive modeling is a key mechanism through which AI impacts learning. Foundational themes like human and article (with high centrality) anchor the research at the intersection of AI and human-centric studies, emphasizing the focus on student experiences. The high density of psychology procedures nursing student suggests specialized applications of AI in healthcare education, potentially involving simulations or personalized learning for nursing students.

The Most Relevant Words list reinforces these findings, with learning (65 occurrences) and artificial intelligence (37 occurrences) as dominant terms, underscoring AI's role in enhancing educational processes. The significant presence of female (52 occurrences) compared to male (15 occurrences, Figure 12) suggests that research may disproportionately focus on female students, possibly exploring how AI tools address gender-specific learning challenges or biases. The limited mention of human experiment (3 occurrences) indicates a gap in empirical studies directly testing AI's impact on student outcomes in live settings, which may limit the robustness of claims about AI's effectiveness. While the thematic analysis highlights AI's potential in predictive and personalized learning, the lack of direct outcome metrics (e.g., grades, retention rates) in the provided data restricts a comprehensive evaluation of its impact. Future research should prioritize experimental designs to

validate AI's effects on student learning outcomes, particularly in underrepresented domains beyond healthcare education.

The Collaboration Network (Figure 10) and Country Collaboration Map (Figure 11) shed light on the global and institutional dynamics of AI-edtech research. The Collaboration Network reveals a diverse group of contributors, including Ahmad, Ramasha (Middle East), Antón-Solanas, Isabel (Europe), and Alahdal, Arif Ahmed (Asia), indicating a global research effort. Clusters like Abbot, Miriam, Bowers suggest interdisciplinary teams, potentially combining expertise in education, technology, and other fields. This diversity implies broad institutional engagement, though the fragmented nature of contributions suggests that collaboration may be opportunistic rather than part of centralized, large-scale initiatives.

The Country Collaboration Map, while lacking detailed geospatial data, aligns with the publication output in Objective 2, where the United States and China dominate. The absence of collaboration intensity data limits insights into the strength of partnerships, but the presence of contributors from multiple regions (Middle East, Europe, Asia) suggests that AI-edtech research is a globally distributed endeavor. However, the lack of representation from African or Central Asian regions, as noted in the Country Scientific Production map (Figure 5), indicates that collaborative networks may exclude less-resourced regions, potentially due to barriers in funding or technological access. The findings highlight the need for more inclusive collaboration frameworks to ensure that AI-edtech research benefits from diverse perspectives and addresses global educational challenges. The fragmented nature of institutional contributions also suggests opportunities for more coordinated efforts, such as international research consortia, to advance the field.

Lastly, the Words' Frequency Over Time analysis (Figure 12) provides evidence of AI's growing influence on teaching methodologies from 2019 to 2023. The consistent growth of terms like artificial intelligence and learning systems reflects the increasing integration of AI tools, such as adaptive learning platforms, into teaching practices. This aligns with the thematic trends in Objective 4, where AI-driven tools are used to personalize education and enhance pedagogical strategies. The rise of learning analytics further indicates a shift toward data-driven teaching methodologies, where instructors leverage AI to monitor student progress and tailor instruction accordingly. It may mean that the term AI in speech is dealing with applications in language processing and could include the use of tools for communication training or automated feedback in language-based courses.

Words such as "Young adult" and "human experiment" specify targeted studies on particular populations and experimental interventions; however, the limited frequency of human experiment (noted under Objective 4) suggests that such studies are not yet widespread. In particular, the vast discrepancy in frequencies between males (15 occurrences) and females (52 occurrences) may indicate a focus of inquiry investigating gender-oriented pedagogies possibly on AI instruments for allaying different learning needs. Overall, the data reveal that the teaching practices have seen a slow but definite shift toward being AI-mediated and evidence-based, with personalization, data analytics, and communication training being in the forefront. However, the lack of comprehensive experimental validation also permits the assessment of the actual usefulness of these methods, thus making a plea for greater rigorous studies to prove the transformative power of AI in educational settings.

VI. CONCLUSIONS

The discussion shows an increasingly fast-moving area of artificial intelligence in university pedagogy, particularly publication growth after November 2022 (Objective 1). Units from the USA, China, and some institutions like the University of California drive this growth (Objective 2). Citation patterns (Objective 3) illuminate the fact that classical papers continue to influence many works but that recent publications are making significant contributions too, especially those published in journals such as Computers in Human Behavior. Emerging issues (Objective 4) are analytics applied to learning, AI-integrating dimensions, and the gendered dimensions thereof, which at this point are still rather limited by empirical verification. Effects of AI on student learning outcomes (Objective 5) are most evident in predictive modeling and in specialized applications, but without direct outcome data. Global collaboration (Objective 6) is uneven and fragmented, however, so it leaves much to be desired in terms of representation from the world's less-resourced regions. Finally, the movement of AI adoption in teaching methods or practices (Objective 7) is toward data-driven personalized learning, with little experimental evidence supporting this trend. Collectively, these findings suggest the growth and promise of the field while creating future research agendas for empirical validation and inclusive collaboration.

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