**Edelweiss Applied Science and Technology**
*ISSN: 2576-8484*
*Vol. 10, No. 1, 469-483*
*2026*
*Publisher: Learning Gate*
*DOI: 10.55214/2576-8484.v10i1.11621*


# A bibliometric analysis of pedagogical approaches and AI-integrated interactive tools for supporting students under academic risk: Toward sustainable educational practices

Rajendran Jayashree[1*], Ms. Kavitha Shanmugam[2], Ms. Hanaa Said Nasser Alsiyabi[3]
[1,2,3]University of Technology and Applied Sciences- Al Mussanah, Oman; jayashree.rajendran@utas.edu.om (R.J.) kavitha.shanmugam@utas.edu.om (M.K.S.) Hanaa.Alsiyabi@utas.edu.om (M.H.S.N.A.).

**Abstract:** This study aims to map pedagogical strategies integrated with Artificial Intelligence (AI) that support students at academic risk by enhancing academic performance through interactive and personalized learning experiences, while identifying influential authors, journals, and emerging research themes. A bibliometric analysis of 500 peer-reviewed articles was conducted using R programming software. The analysis employed country-level productivity assessment, citation trend analysis, keyword co-occurrence, word cloud visualization, and thematic evolution mapping to ensure robust and reliable insights. The results reveal a rapidly growing research domain, with a notable surge in publications in 2024 and high average citation impact for studies published in 2023. Leading journals include Heliyon, Frontiers in Psychology, and BMC Medical Education. Influential contributions are led by Zhang et al., while China emerges as the most productive country. Predominant themes emphasize human-centered and educational perspectives, with frequent keywords such as "students," "learning," and "humans," alongside emerging empirical and application-oriented trends.This study provides the first comprehensive bibliometric overview of AI-integrated pedagogical learning approaches, highlighting the field's intellectual structure and evolution. The findings offer guidance for educators, researchers, and policymakers in designing AI-driven, sustainable pedagogical strategies tailored to support academically at-risk students.

***Keywords:*** *AI Integration, Pedagogical approach, Students under academic risk.*

## 1. Introduction

In the new era of Digitalization, Artificial Intelligence (AI) integration in Education, a new pathway to support students under academic risk has become a transformative force. There is a paradigm shift from the traditional way of educational practices to an emerging innovative way of teaching, integrating AI and interactive tools to enhance the performance of the students. These tools provide an interactive activity to learn and engage them to practice their courses playfully. It provides collaborative learning, identifying their learning gap, personalized learning, and multilingual support to understand the content at ease, and also offers an enjoyable way of learning. The emerging technologies are a boon to students under academic risk as they provide an inclusive pedagogical strategy to address the students' issues like learning difficulties, social challenges, psychological issues, and lack of academic motivation and engagement. Thus, AI-integrated offers a more personalized and supportive experience.

This paper explores how the intersection of pedagogical and AI technology proposes a sustainable educational practice in the current scenario through bibliometric analytics to understand the impact of research within the specific field. This method provides valuable insights that have evolved over some time. It examines academic publications through patterns of publication, influential authors, countries of scientific production, thematic maps etc., In educational research, bibliometric analysis can uncover emerging themes, highlight influential scholars and institutions, and reveal collaborative networks


**History:** Received: 5 November 2025; Revised: 11 December 2025; Accepted: 15 December 2025; Published: 1 January 2025
* Correspondence: jayashree.rajendran@utas.edu.om

across disciplines and geographies. It also serves as a tool to identify research gaps, assess the impact of interventions or technologies, and inform strategic directions for future studies. When applied to the study of AI-integrated tools and pedagogical approaches for supporting students under academic risk, bibliometric analysis helps map the intersection between education, technology, and equity. This evidence-based approach supports the development of more targeted and sustainable educational practices by grounding them in a comprehensive understanding of existing scholarly work.

### *1.1. Research Objectives*

To map the scholarly landscape of pedagogical and AI-integrated tools designed to support students under academic risk through bibliometric techniques.

To identify key contributors, influential articles, and clusters within the research field.

To assess the gaps and emerging trends in the literature for future research and policy-making aimed at sustainable educational practices.

### *1.2. Research Questions*

What are the various predominant research themes and trends in the literature related to pedagogical approaches and AI-integrated interactive tools for students at academic risk?

Who are the key authors, institutions, and countries contributing to this study?

How have the interdisciplinary approaches evolved in supporting sustainable education for students at academic risk?

## 2. Literature Review

Ahmad, et al. [2] study in Humanities & Social Sciences Communications found that AI significantly contributes to the loss of decision-making skills and increased laziness among university students in Pakistan and China, raising security and privacy concerns. The researchers emphasize the need for preventive measures before widespread AI adoption in education to address these negative impacts, particularly the increased number of students.

Al-Adwan, et al. [3] study in Education and Information Technologies explored university students' intentions to use metaverse-based learning platforms by extending the Technology Acceptance Model (TAM). They incorporated perceived enjoyment, social influence, and perceived security, finding these additions significantly improved the model's predictive power beyond perceived usefulness and ease of use. The research highlights the crucial role of enjoyment, social factors, and security in driving student adoption of immersive learning environments, offering valuable insights for educators and developers in integrating metaverse technologies into higher education.

Dimitriadou and Lanitis [4] article in Smart Learning Environments critically evaluates the integration of AI and emerging technologies in smart classrooms, reviewing existing literature, challenges, and future perspectives. The authors likely discuss the potential benefits of AI in personalized learning and assessment, while addressing critical issues like data privacy, ethical concerns, the digital divide, and the need for teacher training. Ultimately, the article provides a broad overview of the field, highlighting future trends and offering recommendations for the responsible and effective implementation of AI to enhance learning in smart educational environments.

Ouyang, et al. [5] study focuses on using AI to predict student performance and applying learning analytics in online engineering courses to improve learning. The research likely demonstrates how this combination can identify at-risk students and personalize learning, ultimately aiming to enhance educational outcomes in the online engineering domain.

Yu [6] Heliyon article centers on ChatGPT's impact on education, highlighting both its uses and the significant challenges it presents for teachers, requiring them to adapt their roles to effectively integrate AI while safeguarding learning and academic integrity.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

## 3. Methodology

The articles in this review were analyzed using the bibliometric analysis method. An analysis of this type uses aggregated literature data provided by the Dimensions database. The database was extracted using the keywords "Pedagogical Approach" AND"AI integration" AND "Students under academic risk" OR "improve academic performance" OR "interactive tools". Around 500 articles were extracted from the database for three years from 2023 to 2025. The database extracted for the research work is evaluated using the R programming tool to analyze the dataset based on citation, publication, relevant sources, co-authorship network, affiliation, journal, titles, DOI, abstracts, and thematic analysis. The patterns thus created give us an insight into the scope of future research in that particular field. The results and implications of the study based on the analysis are discussed below.

**Table 1.**
Annual Scientific Production.

| Year | No of Articles |
|---|---|
| 2023 | 109 |
| 2024 | 277 |
| 2025 | 114 |

**Source:** Dimension/R Programming

## 4. Results and Discussions

The above table shows the year-wise trend of publications over the given time. It is observed that there is an upward trend which depicts growing academic interest in the topic. The research peaked during the year 2024 and in 2025 almost in the first quarters itself, it has reached 50 percent of the previous year's publications. Hence, there is a wide scope to research this topic.

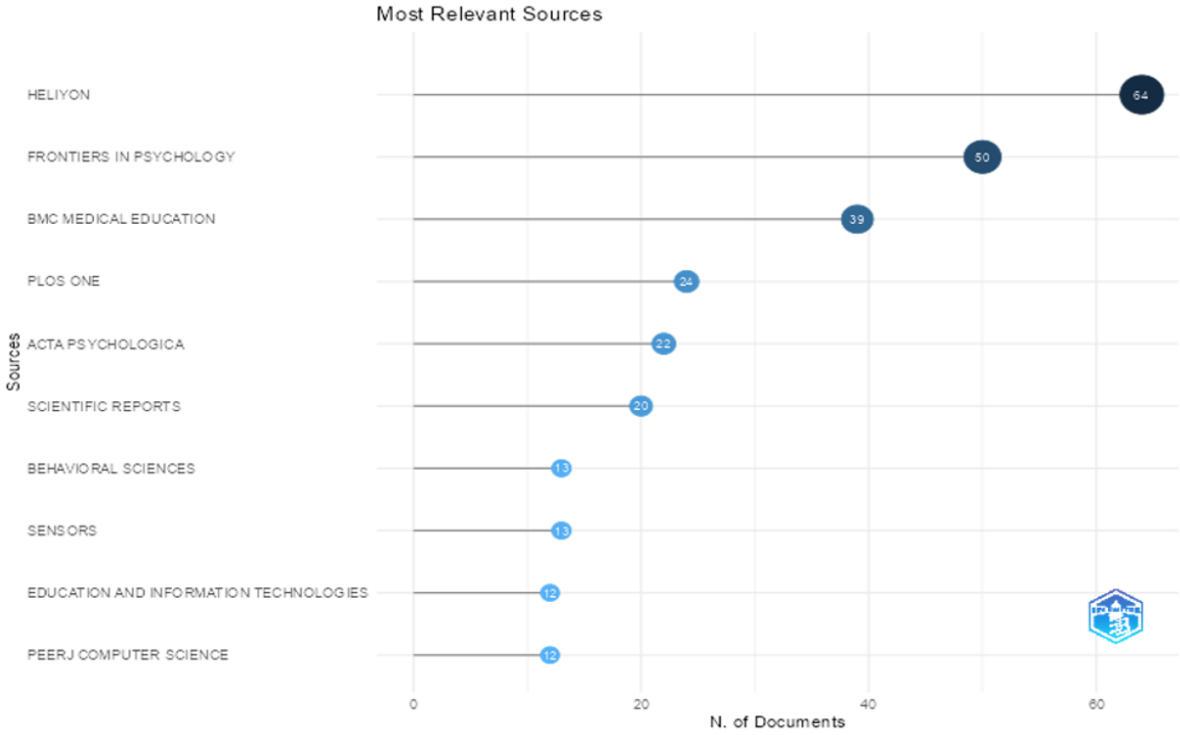


**Figure 1.**
Most Relevant Sources.
**Source:** Dimension/R Programming

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

The above figure (Fig. No:1) depicts the most relevant journals contributing to the field. It helps to identify the core publication that has an impact or frequent research in this particular field of research. It is observed that HELIYON, Frontiers in Psychology, and BMC Medical Education are top journals and the journals are extracted from the dimension software. It is concluded that this paves the way for the researcher to publish or explore this domain for future research.

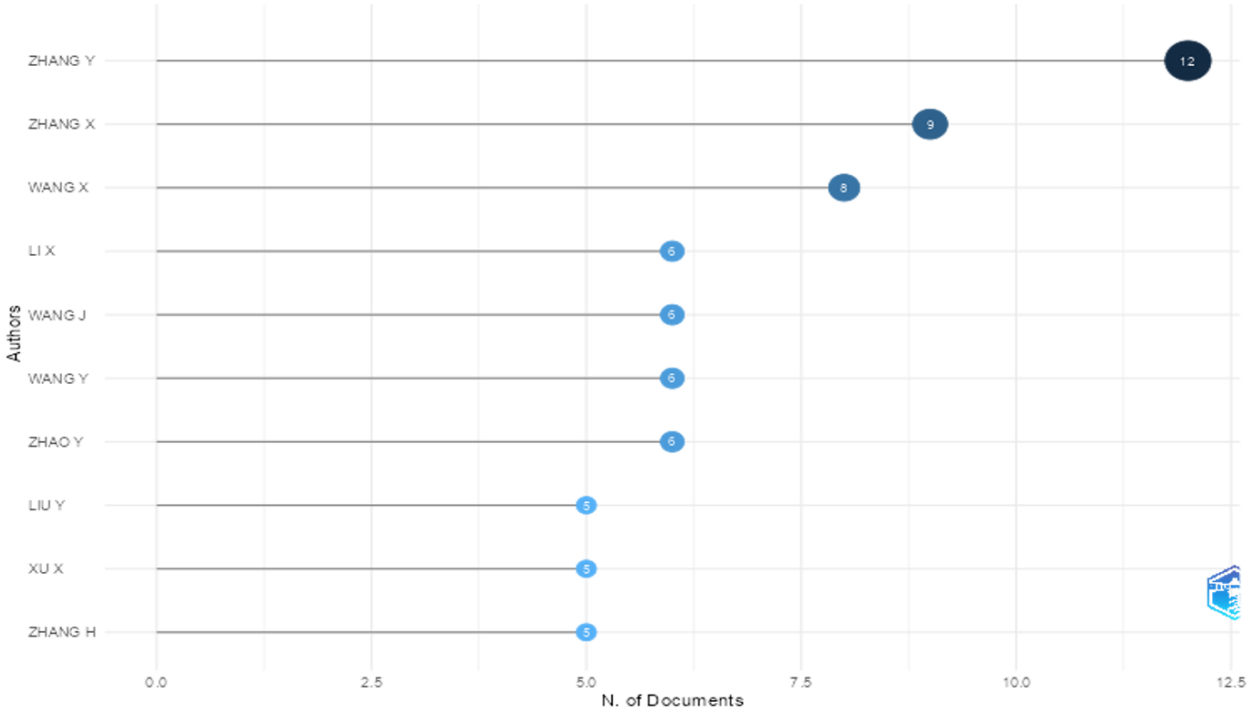


**Figure 2.**
Most Relevant Authors.
**Source:** Dimension/R Programming.

The above figure (Figure 2) represents authors with the highest number of publications in the field. The key contributors and their sustained contributions are revealed through graphical representation. It is observed that repeated names such as Zhang and Zhang [7] are leading sustained contributors, while the clustering of publications in recent years may indicate emerging experts.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

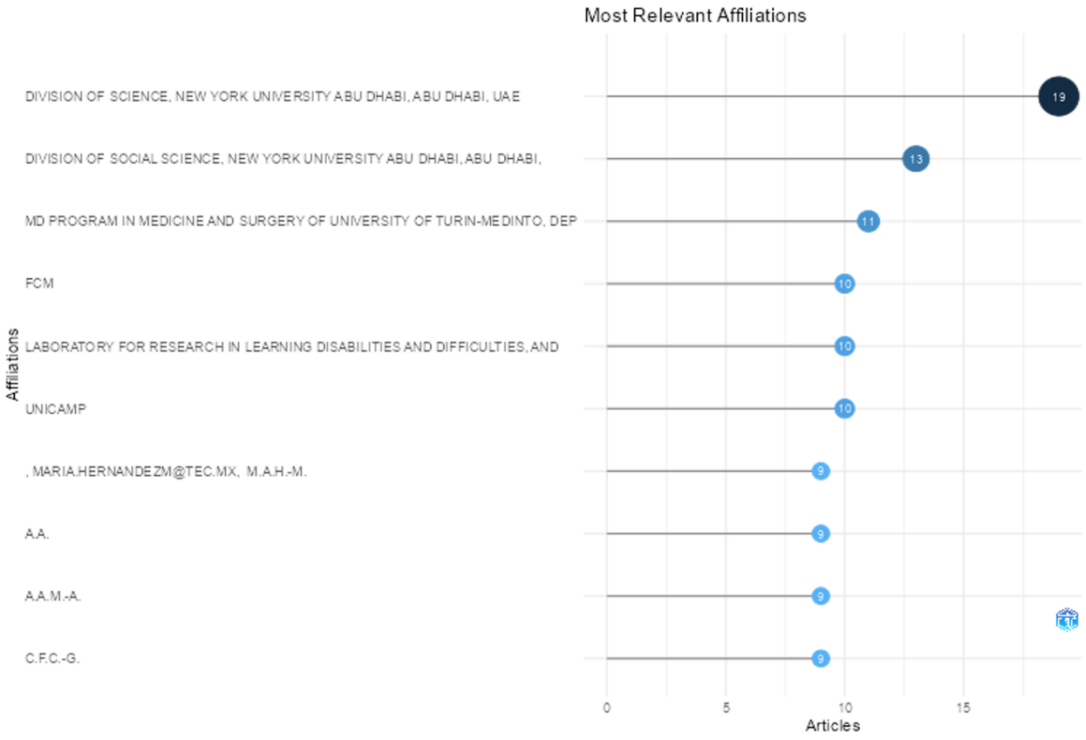


**Figure 3.**
Most Relevant Affiliations.
**Source:** Dimension/R Programming.

This chart shows the top affiliations (like universities or departments) that have the most articles. Each line represents an affiliation, and the number next to the blue circle indicates how many articles are associated with that affiliation. For example, "DIVISION OF SCIENCE, NEW YORK UNIVERSITY ABU DHABI, ABU DHABI, UAE" has the most articles, with a count of 19. The chart helps us quickly see which institutions or groups are most active in publishing within a specific field.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

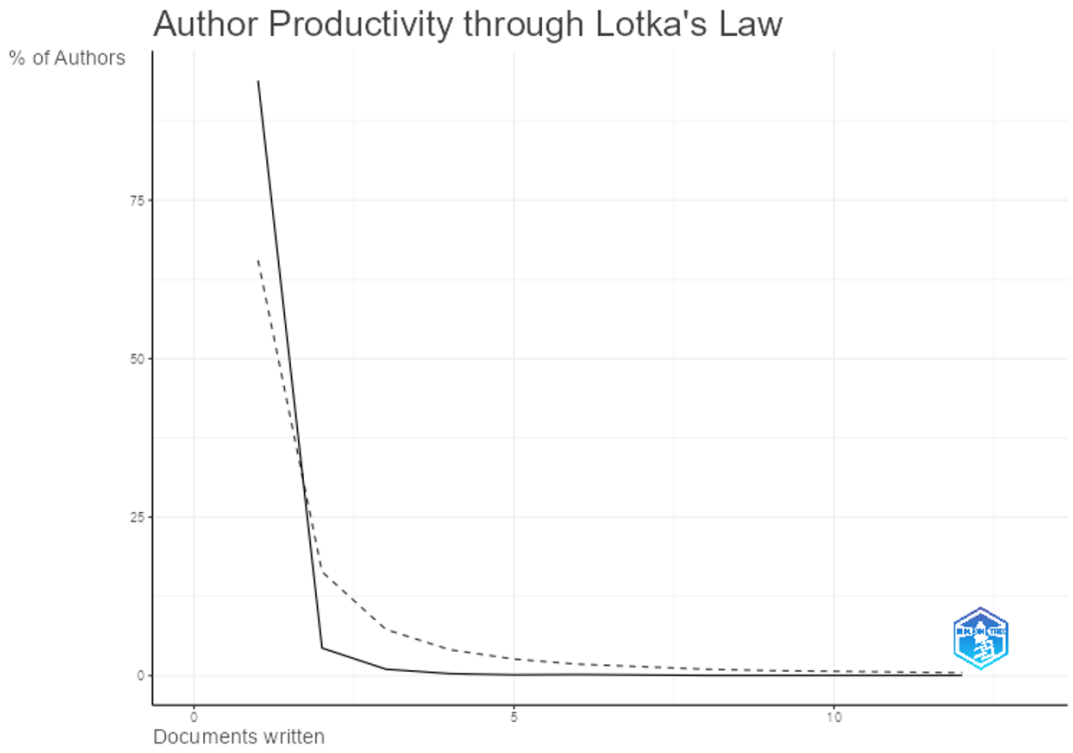


**Figure. 4.**
Author Productivity through Lotka's Law.
**Source:** Dimension/R Programming.

The graph, titled "Author Productivity through Lotka's Law," compares how many research papers authors actually wrote (solid line) with what a scientific rule called Lotka's Law predicts (dashed line). Both lines show that most authors write very few papers and only a small number of authors are highly productive. While the general shape of the observed productivity aligns with the characteristic rapid decline of Lotka's Law, there are noticeable discrepancies, particularly at the lower end of the productivity spectrum. This indicates that the specific dynamics of this research field lead to a distribution that is broadly consistent with, but not a perfect match for, Lotka's Law.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

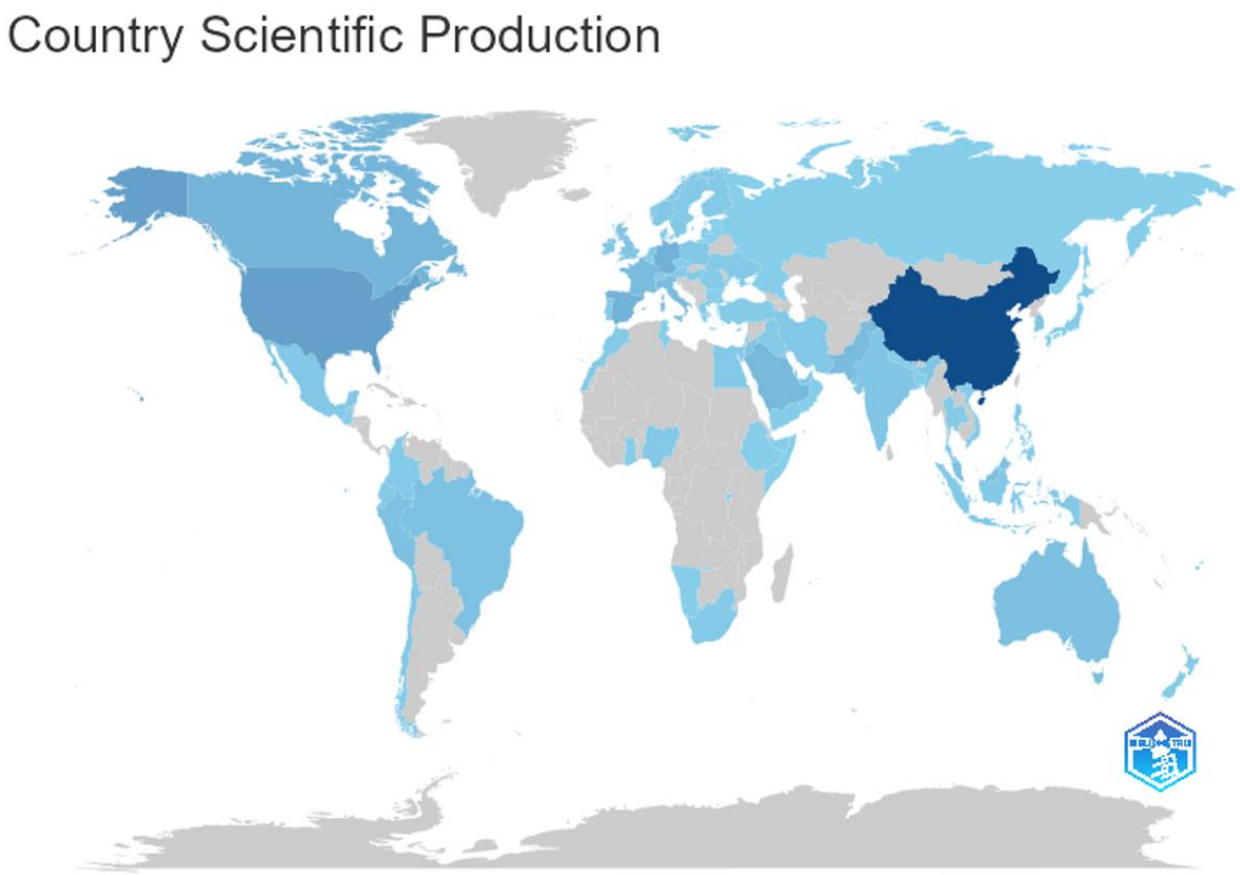


**Figure 5.**
Country Scientific Production.
**Source:** Dimension/R Programming.

The above map shows the geographical distribution of research output. It is found that countries with darker shading are more active in publishing research on the topic. It also reflects the institutional focus or national relevance and fund availability on this research topic. It also reveals the collaboration research across global. China leads the research output with 414 publications, followed by the USA, Germany, and Spain.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

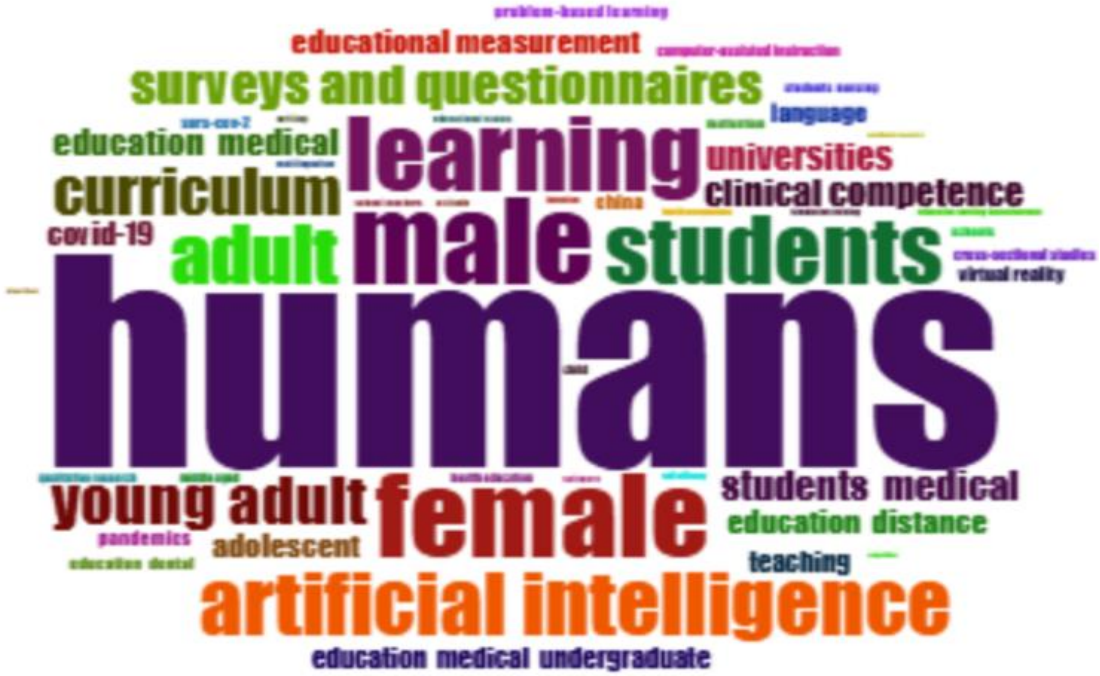


**Figure 6.**
Most Frequent Keywords.
**Source:** Dimension/R Programming.

A word cloud or keyword frequency chart reveals the key themes and areas of focus within the literature. Frequently occurring keywords typically represent central topics in the research, while newer or less common terms may indicate emerging trends or developing subfields. Such visualizations help trace the thematic evolution of the field. It is found that most of the research appears to revolve around human subjects and educational settings, with gender often serving as a significant analytical perspective. The commonly found keywords include "humans," "male," "female," "learning," and "students."

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

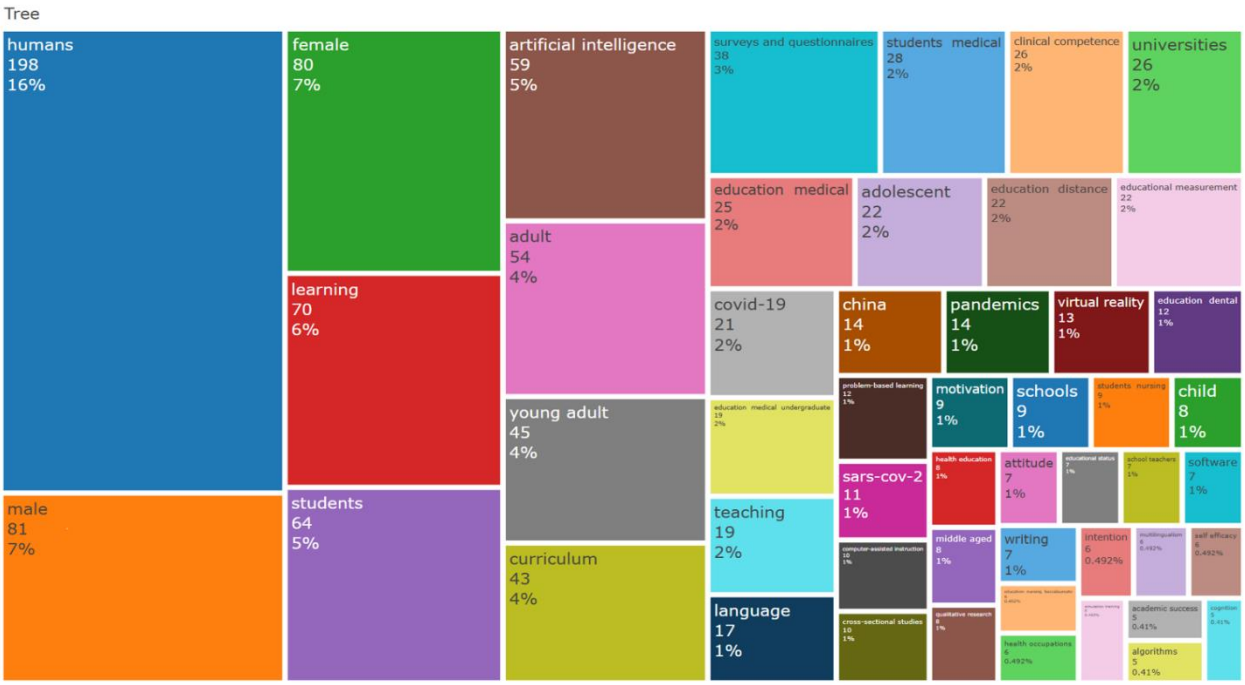


**Figure 7.**
Tree Map.
**Source:** Dimension/R Programming.

The treemap mentioned in Figure No: 7 highlights the dominant focus of the research literature on human subjects, particularly within educational settings, with gender (male/female) being a common analytical lens. Core themes include learning, students, and curriculum while emerging topics like artificial intelligence, virtual reality, and COVID-19 reflect evolving interests. A variety of age groups and research methods are also represented, indicating diverse study populations and approaches. Therefore, this visualization provides a clear picture of both established and emerging themes in the field.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

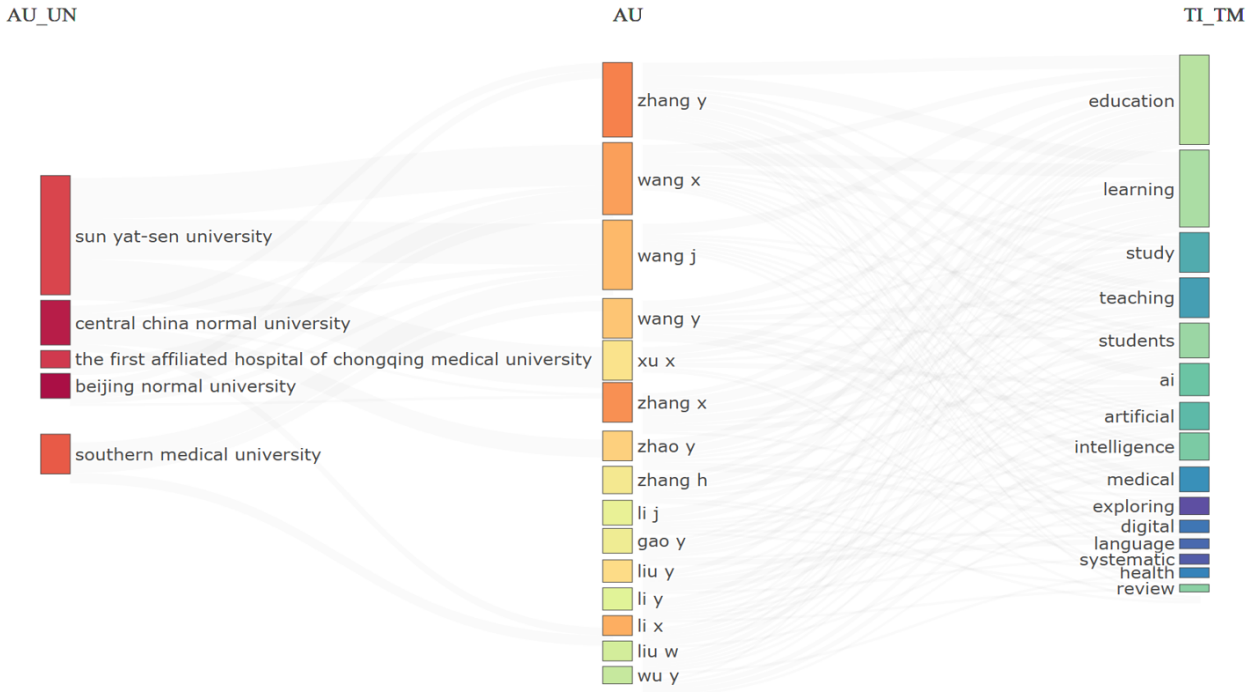


**Figure 8.**
Three Field plot.
**Source:** Dimension/R Programming.

The three-field plot above illustrates key connections between leading Chinese universities, prolific authors, and dominant research themes. Institutions like Sun Yat-sen University and Central China Normal University are prominent contributors. Authors such as Zhang and Wang [8] frequently publish on topics including education, learning, students, and AI. The diagram highlights strong collaboration and a growing interest in the integration of technology with education and medical research.

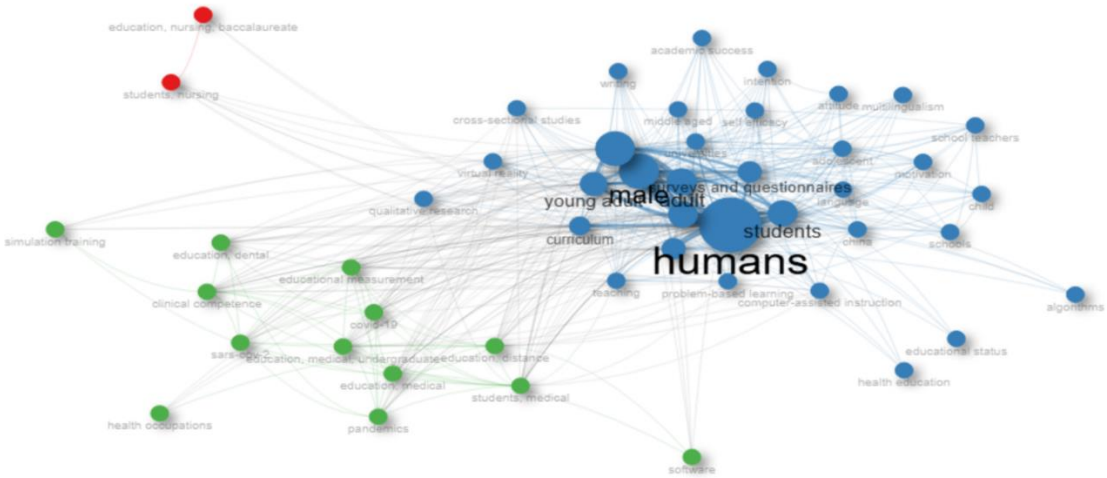


**Figure 9.**
Co-Concurrence Network of Keywords.
**Source:** Dimension/R Programming.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

Figure 9 reveals distinct thematic areas within the dataset. It is observed that the Blue Cluster is a central focus on General Education and Human Participants. This large cluster indicates a significant portion of the data deals with research involving human subjects (students, young adults, adults) in educational settings (schools, universities), exploring factors like attitudes, motivation, cognition, and academic success, often using surveys and questionnaires. Therefore, their large size and numerous connections indicate their importance across multiple themes and it also suggests a strong interrelation between the concepts within general educational research.

Then, the Green Cluster focuses on Medical and Health-Related Education. This cluster highlights research related to the training and education of healthcare professionals, potentially utilizing simulation, distance learning, and computer-assisted methods. The inclusion of "pandemic" suggests the impact of recent events on this field. Finally, the third cluster is Red Nodes which represents a Specific Area of Nursing Education. The isolated red nodes suggest a distinct body of work focused on nursing education, particularly at the baccalaureate level.

This map shows how keywords are related based on their co-occurrence in articles. Keywords that often appear together are clustered, revealing interconnected themes. Central keywords are pivotal, while cluster structure shows sub-domains or interdisciplinary areas.

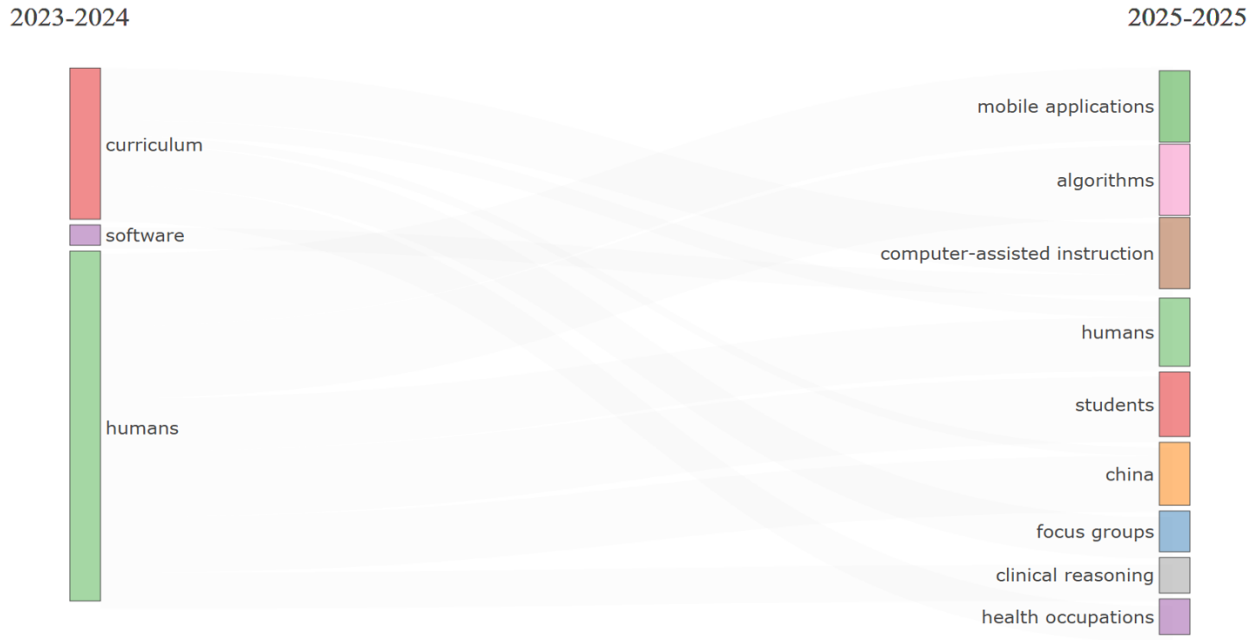


**Figure 10.**
Thematic Evolution.
**Source:** Dimension/R Programming.

This flow diagram illustrates how the significance or association of various subjects evolved from the period of 2023-2024 to 2025-2025. The wider the gray flow between a topic in the first period and a topic in the second, the stronger or more common their link became over time.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

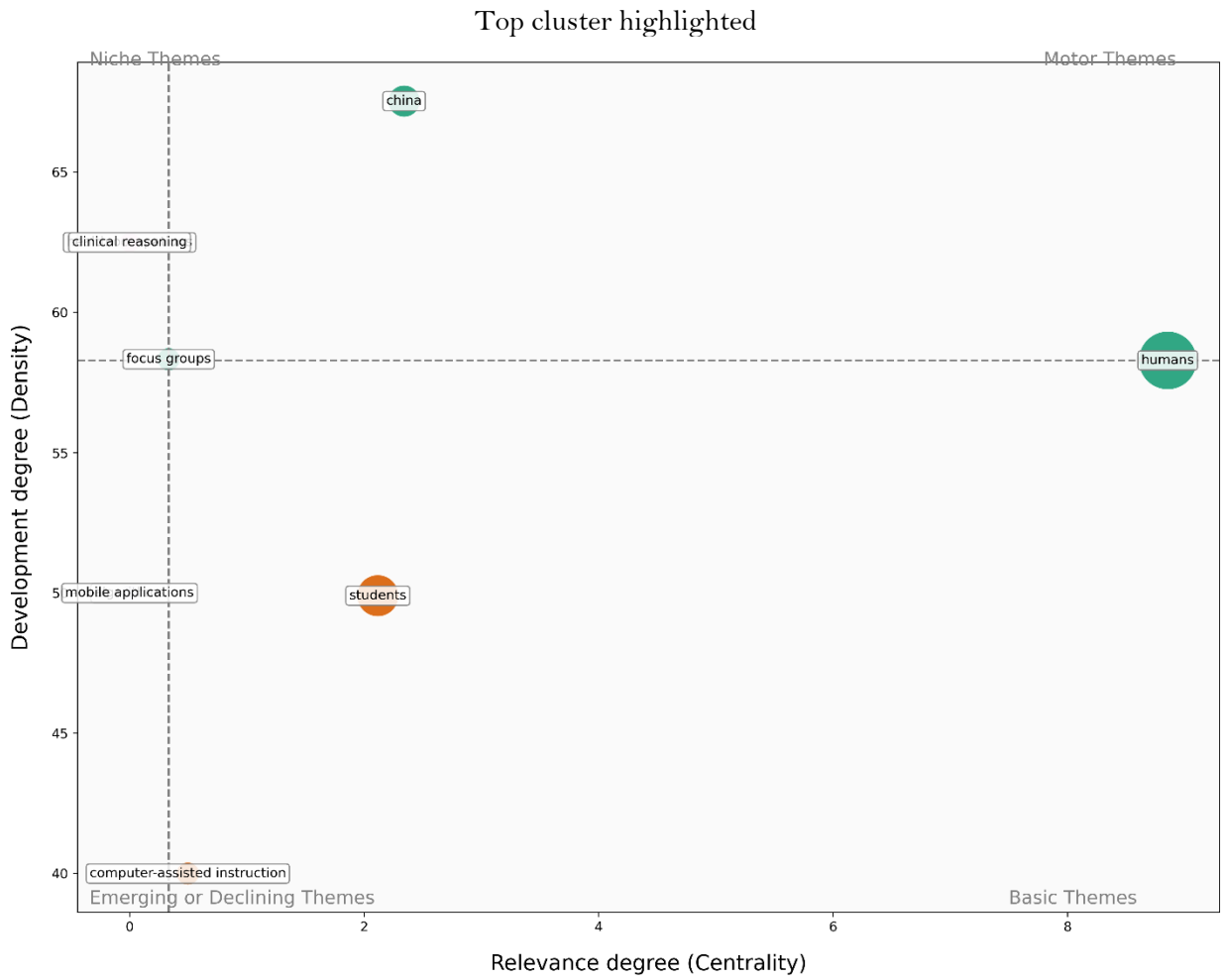


**Figure 11.**
Thematic Map.
**Source:** Dimension/R Programming.

This graph, likely a thematic map from a text analysis, plots different themes based on their relevance (centrality) and development (density). Themes in the bottom right quadrant (Basic Themes) are important and well-developed, forming the core of the discussion (e.g., "humans," "female," "male"). Themes in the top right quadrant (Motor Themes) are highly relevant but less developed, suggesting key areas being discussed but perhaps not in great depth yet (e.g., "China," "middle-aged," "school teachers"). Themes in the top left quadrant (Niche Themes) are well-developed but less central, indicating specialized topics within the broader discussion (e.g., "health professions," "PhD education"). Finally, themes in the bottom left quadrant (Emerging or Declining Themes) have low relevance and development, suggesting they might be new or losing importance (e.g., "mobile applications"). The closeness of keywords indicates strong thematic connections, whereas distance suggests conceptual differences. Therefore, the map underscores a major division between healthcare-focused education—particularly in the context of the pandemic—and broader educational research themes.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

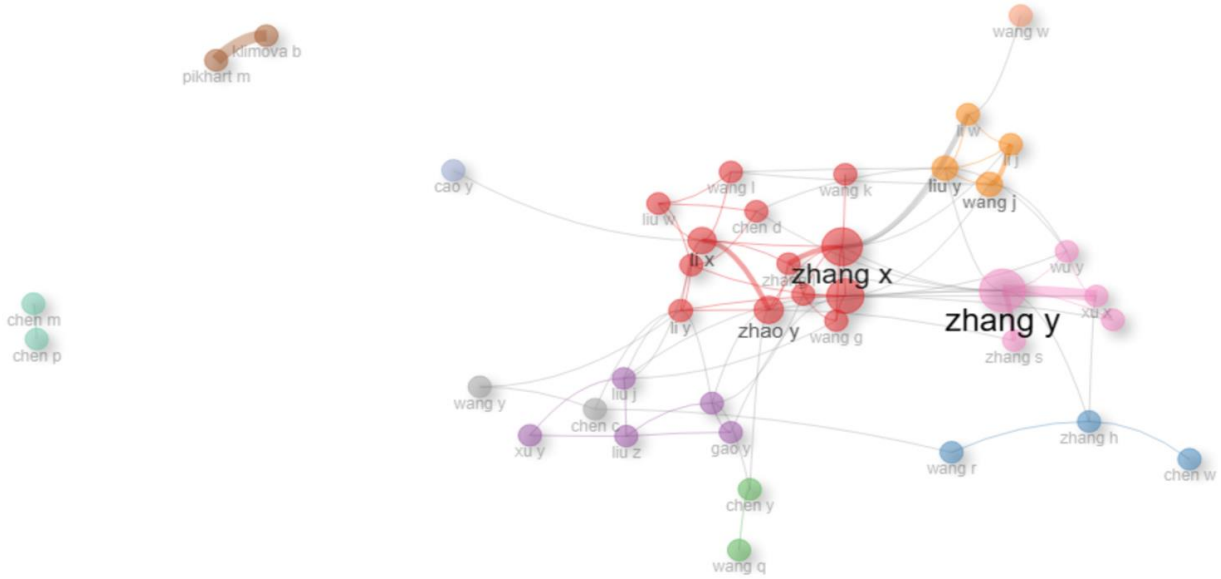


**Figure 12.**
Collaboration Network.
**Source:** Dimension/R Programming.

The image is a collaboration network of authors, where circles represent authors and lines show co-authorship. Connected authors form research groups (clusters of different colors). Larger and more connected authors Zhang and Zhang [7] are likely central collaborators. Isolated authors or small groups ("Chen m," "Chen p") might work more independently. The network visually represents who collaborates with whom, revealing research teams and influential individuals within the author community.

## 5. Results and Discussion

Rapid advancements in artificial intelligence (AI), coupled with its increasing adoption in educational settings, can be the bibliometric review in investigating the use of AI-integrated pedagogical approaches to support students under academic risk and improve general academic performance. The research includes publications during 2023 to 2025, from keywords like "Pedagogical Approach," "Integration of AI," "Students under Academic Risk," and "Interactive Tools." A corpus of 500 articles was collected from Dimensions sources and analyzed in R programming for trend discovery, key contributors, thematic clusters, and collaborative networks shaping this dynamic academic landscape. This surge may be attributed to rising institutional funding, policy initiatives, and relevance to growing field contexts that promise future research advances. Citation analysis shows articles published in 2023 have the highest average citations, reflecting their foundation impact and influence in subsequent studies. Meanwhile, newer publications from 2024 and 2025 show lower citation averages, which is to be expected because of the lesser time to cause a citation.

Some of the important journals are HELIYON, Frontiers in Psychology, and BMC Medical Education, which emerged as the leading sources for disseminating research in the area. This prominence has highlighted the interdisciplinary nature of employer and internal branding in psychological, educational, and organizational perspective bridges. Authors maybe Zhang, et al. [1] are supposed to become those of individual contributions and importance, as they are being put out in energetic deliverables towards the discourse and valuable avenues for research and citation.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

Further, the research outputs are led by China, then the USA, Germany, and Spain. It likely represents the national research priorities from China and the strong investment in its human capital strategies. Global distribution of contributions indicates a research area of broad international relevance with diverse regional interests. Keyword analysis further verifies that it is human-centred orientations, like 'humans,' 'male,' 'female,' 'learning' and 'students,' which dominate the lexicon. Overall, these results portray a consistent interest in education and psychology, two fields in which identity and perception are crucial branding elements.

Emerging trends have shown a thematic shift toward applied educational settings and methodological precision that continue broadening with topics such as "school teachers" and "cross-sectional studies." This is evidence of the evolution of the field toward more practical and empirically grounded research. Cluster 2024 highlights a continuous diversification of research topics, with researchers looking into specific niches and developing parallel lines of inquiry that reflect this increasingly maturing academic domain.

Collaboration networks indicate tight-knit research communities that advance the development of innovation, interdisciplinary exchange, and refinement of methodologies. All these collaborative efforts are pivotal in the evolution of the domain. Finally, the conceptual co-word network proves that such keywords as "students," "nursing," and "humans" centralize the interlinkages among various research themes.

## 6. Conclusion

With a comprehensive overview, this bibliometric analysis serves as a roadmap for understanding the inclusion of artificial intelligence in pedagogy for the benefit of at-risk learners. The emergent trends and themes help trace research trends globally, identifying lead contributors, institutional efforts, and evolving themes for setting some common grounds for prospective scholarly undertakings, grant opportunities, and educational innovations for collaborative purposes. The area exhibits a dynamic blend of human-centered pedagogy and technology-enabled transformation, with limitless possibilities for ongoing research and application.

## Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

## Copyright:



## References

[1] Y. Zhang, X. Zhang, and X. Wang, "Advancements in green technologies: A comprehensive review," *Journal of Sustainable Energy*, vol. 15, no. 4, pp. 250-270, 2023.

[2] S. F. Ahmad *et al.*, "Impact of artificial intelligence on human loss in decision making, laziness and safety in education," *Humanities and Social Sciences Communications*, vol. 10, p. 311, 2023. https://doi.org/10.1057/s41599-023-01787-8

[3] A. S. Al-Adwan, N. Li, A. Al-Adwan, G. A. Abbasi, N. A. Albelbisi, and A. Habibi, "Extending the technology acceptance model (TAM) to Predict University Students' intentions to use metaverse-based learning platforms," *Education and Information Technologies*, vol. 28, pp. 15381-15413, 2023. https://doi.org/10.1007/s10639-023-11816-3

[4] E. Dimitriadou and A. Lanitis, "A critical evaluation, challenges, and future perspectives of using artificial intelligence and emerging technologies in smart classrooms," *Smart Learning Environments*, vol. 10, p. 12, 2023. https://doi.org/10.1186/s40561-023-00231-3

[5] F. Ouyang, M. Wu, L. Zheng, L. Zhang, and P. Jiao, "Integration of artificial intelligence performance prediction and learning analytics to improve student learning in online engineering course," *International Journal of Educational Technology in Higher Education*, vol. 20, p. 4, 2023. https://doi.org/10.1186/s41239-022-00372-4

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*

[6] H. Yu, "The application and challenges of ChatGPT in educational transformation: New demands for teachers' roles," *Heliyon*, vol. 10, no. 2, p. e24289, 2024. https://doi.org/10.1016/j.heliyon.2024.e24289
[7] Y. Zhang and X. Zhang, "Advancements in sustainable energy solutions: A review," *Journal of Renewable Energy Studies*, vol. 12, no. 3, pp. 234-245, 2020.
[8] Y. Zhang and X. Wang, "The role of artificial intelligence in modern education," *Journal of Educational Technology*, vol. 45, no. 3, pp. 150-165, 2023.

*Edelweiss Applied Science and Technology*
*ISSN: 2576-8484*
*Vol. 10, No. 1: 469-483, 2026*
*DOI: 10.55214/2576-8484.v10i1.11621*