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UNVEILING THE GLOBAL RISE OF CHATBOT-ASSISTED LEARNING A 2020–2025 BIBLIOMETRIC STUDY

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ABSTRACT

Background: Chatbot-Assisted Learning (CbAL) is an innovative educational approach that leverages AI-driven chatbots to deliver personalised, interactive learning experiences. This bibliometric study maps the intellectual landscape and evolutionary trends of CbAL research from 2020 to 2025, a period significantly shaped by advances in generative AI. Methods: Utilising a dataset of 253 peer-reviewed articles from the Dimensions AI database, the analysis employs co-authorship, citation, and bibliographic coupling techniques to examine the field's development. Results: The results reveal a field in rapid expansion, with a 45% surge in citations after 2022 and a publication peak in 2024, directly linked to the influence of models like ChatGPT. Geographically, research is heavily concentrated, with the Asia-Pacific region spearheaded by China (192 articles, 7,773 citations), contributing 76% of the output, highlighting a pronounced global research divide. Thematic analysis reveals robust clusters in Technical Foundations (32%) and Pedagogical Applications (28%), indicating a strong connection between innovation and educational practice. However, the cluster on Emerging and Ethical Considerations remains significantly underdeveloped (5%), indicating a critical gap. Conclusion: The study concludes that while CbAL has achieved remarkable technical maturity, its future trajectory must be consciously steered. Prioritising global collaboration to bridge geographical inequities and embedding interdisciplinary ethical rigour are imperative to ensure the equitable and responsible development of chatbot-assisted learning for diverse educational contexts worldwide.

KEYWORDS: Bibliometric Analysis, Chatbot-Assisted Learning, Educational Technology, Generative AI, ChatGPT, Global Collaboration, Research Trends.

1. INTRODUCTION

The integration of Artificial Intelligence (AI) into educational ecosystems has catalysed a paradigm shift, moving beyond traditional instructional methods towards more dynamic, personalised, and interactive learning experiences (Z. Wang, 2025). Among the various AI-driven innovations, chatbots have emerged as potent tools, fundamentally altering the teacher-student dynamic and the mechanics of knowledge acquisition (Honaker, 2025). These AI-powered conversational agents, often underpinned by sophisticated natural language processing (NLP) and large language models (LLMs), offer unprecedented capabilities for providing real-time feedback (Kusumastuti, 2024;), facilitating adaptive learning pathways, and supporting collaborative problem-solving. This paradigm, broadly termed Chatbot-Assisted Learning (CbAL), holds significant promise for enhancing educational outcomes by making learning more accessible, engaging, and tailored to individual student needs (Choudhury, 2025).

The global interest in CbAL has witnessed an exponential surge, particularly following the public release of generative AI models like ChatGPT in late 2022 (Alzahrani & Alzahrani, 2025). This "post-ChatGPT era" has triggered a flood of research exploring the pedagogical applications, effectiveness, and implications of these technologies across diverse disciplines (Liu et al., 2025), from language learning and computer science to healthcare education (Sharma et al., 2025). Consequently, the scholarly literature on CbAL has expanded at a rapid and complex pace, generating a vast and fragmented body of knowledge (Greenagel, 2025). This deluge of publications necessitates systematic efforts to map the intellectual landscape, identify core contributors, and delineate evolving trends to guide future research and policy (Huang et al., 2022).

While the pedagogical impact of CbAL has been extensively discussed, a comprehensive, macro-level understanding of the research landscape itself remains underexplored. Several literature reviews and systematic analyses have been conducted (Deng & Yu, 2023), but they often rely on traditional bibliographic databases like Scopus and Web of Science. This reliance potentially overlooks significant patterns within the burgeoning open-access literature and emerging databases such as Dimensions AI, which offers a more inclusive and comprehensive coverage of scientific outputs, including patents and data papers (Zhang et al., 2024). Furthermore, existing bibliometric studies in this domain predate the transformative impact of advanced LLMs, leaving a critical gap in our understanding of the contemporary research trajectory, collaboration networks, and thematic evolution in the CbAL field from 2020 to 2025.

The burgeoning interest in chatbot-based learning has precipitated a substantial body of research examining its efficacy, diverse applications, and underlying methodologies (Hackett, 2025). This corpus has experienced significant growth, particularly in the post-2020 era, necessitating systematic approaches to synthesise the evolving research landscape (Sraman, 2025). However, this rapid expansion has also revealed critical lacunae. While existing bibliometric analyses have provided foundational insights, many rely on traditional databases and predate the transformative impact of advanced large language models (Huang et al., 2022), leaving the contemporary research trajectory underexplored (Greenagel, 2025).

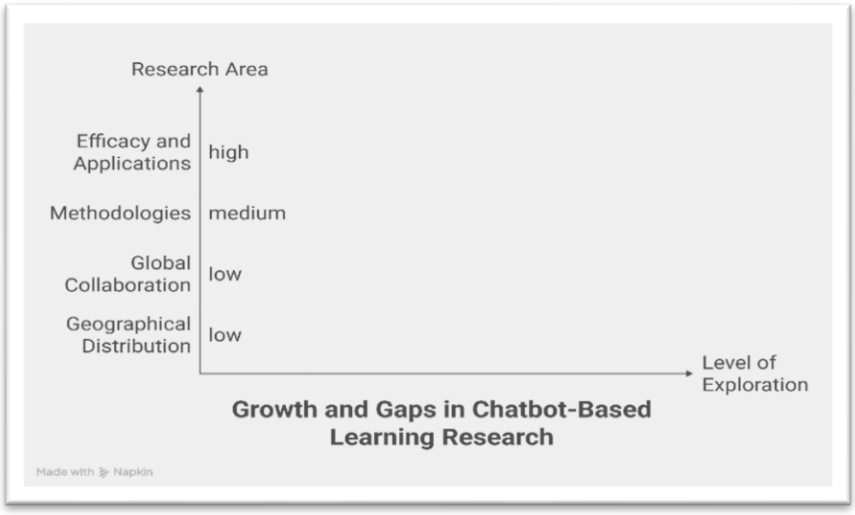

Figure 1: Global Trends in Cbal.

This gap is further compounded by a lack of detailed investigation into the global collaboration patterns and geographical distribution of CbAL research. Understanding which countries and institutions are leading the effort, the nature of their collaborative networks, and the regions that are underrepresented is crucial for fostering inclusive and equitable advancements in AI for education (Deng & Yu, 2023). The current concentration of research in technologically advanced nations risks creating a "digital divide" in pedagogical research, potentially leading to AI tools that are not representative of diverse global educational contexts (Kindenberg, 2025).

Therefore, this study seeks to address these lacunae by conducting a rigorous bibliometric analysis of CbAL research from 2020 to 2025, utilising the expansive Dimensions AI database. This platform was selected for its authenticity and advanced capabilities in aggregating a wide array of scientific outputs, thereby facilitating a comprehensive review beyond the scope of conventional indexes. The investigative framework of this research is structured around three core bibliometric techniques, co-authorship analysis, citation analysis, and bibliographic coupling, to map the intellectual structure and social dynamics of the field, as illustrated in Figure The study is justified by the pressing need to systematically map the post-2020 research explosion, identify the most influential actors and networks, and highlight geographical and thematic disparities. By employing these techniques, this research aims to provide a data-driven snapshot of the CbAL domain. The findings will offer valuable insights for researchers, policymakers, and educational stakeholders, helping to consolidate knowledge, identify emerging frontiers, and promote a more globally collaborative and ethically informed approach to integrating chatbots in education.

1.1. Objectives Of the Study

The primary objective of this research is to conduct a comprehensive bibliometric analysis to map the intellectual landscape and evolutionary trends of Chatbot-Assisted Learning (CbAL) research from 2020 to 2025. To achieve this overarching aim, the following specific objectives have been formulated:

1. To analyse the volume, growth trajectory, and disciplinary distribution of scientific publications on Chatbot-Assisted Learning (CbAL) during the specified period.
2. To map the global collaborative network structures within the CbAL domain by conducting a co-authorship analysis at the country level.
3. To identify the most influential contributors and foundational works in the field through citation analysis of key authors, publications, and countries.
4. To uncover the intellectual themes and conceptual structure of CbAL research by performing a bibliographic coupling analysis of documents and countries.
5. To identify emerging research frontiers, thematic gaps, and potential future directions for CbAL scholarship, with a focus on geographical equity and ethical considerations.

2. RESEARCH METHODOLOGY

Research Design and Data Source: This study employed a descriptive and quantitative bibliometric research design to systematically map the intellectual landscape and scholarly output of Chatbot-Assisted Learning (CbAL) research (Zhang et al., 2024). The analysis was conducted on metadata of scientific publications retrieved from the Dimensions AI database, a platform recognised for its extensive coverage of interdisciplinary research, including publications, datasets, grants, and patents. The design facilitates the identification of publication trends, influential contributors, collaborative networks, and the conceptual structure of the field through quantitative indicators and network analysis (Buschmann, 2024).

2.1. Search Strategy and Screening Process

The primary data source for this analysis was the Dimensions AI database. A systematic search was performed to gather relevant literature. The search query was constructed to capture publications focused on the core concept of Chatbot-Assisted Learning.

The following key filters were applied to refine the results to the most relevant and high-quality literature for analysis:

Table 1 effectively demonstrates the systematic narrowing of the dataset from a broad initial search to a focused, high-quality final corpus of 253 peer-reviewed journal articles for analysis.

The identification and screening of relevant studies for this bibliometric analysis followed a systematic process outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Rastogi et al, 2025). Figure 2 illustrates the flow of information through the different phases of the literature search and selection. The process involved an initial search in the Dimensions AI

database, followed by the removal of duplicates and a multi-stage screening against pre-defined inclusion and exclusion criteria (detailed in Table 1) to arrive at the final dataset for analysis

Table 1: Data Retrieval and Screening Criteria.

Filter Category	Criteria Applied	Documents Remaining	Document Type
Initial Search	Search String: "Chatbot-Assisted Learning", "Educational Chatbot"	48,371	Mixed (Articles, Patents, etc.)
Publication Years	2021 – 2025	43,922	Mixed
Subject Areas	Information and Communication, Education, Human-Centred Communication, Pedagogy and Curriculum	26,637	Mixed
Sustainable Development Goal (SDG)	SDG 4 - Quality Education	6,115	Mixed
Publication Type	Article (Primary Research)	3,227	Article
Source Title	Education and Information Technologies, Computers & Education, Interactive Learning Environments, Education Sciences, Journal of Computer Assisted Learning	557	Article
Journal List	ERA2023, ERIH Plus, UGC Care, VABB-SHW, Directory of Open Access Journals (DOAJ)	253	Article (Final Dataset)

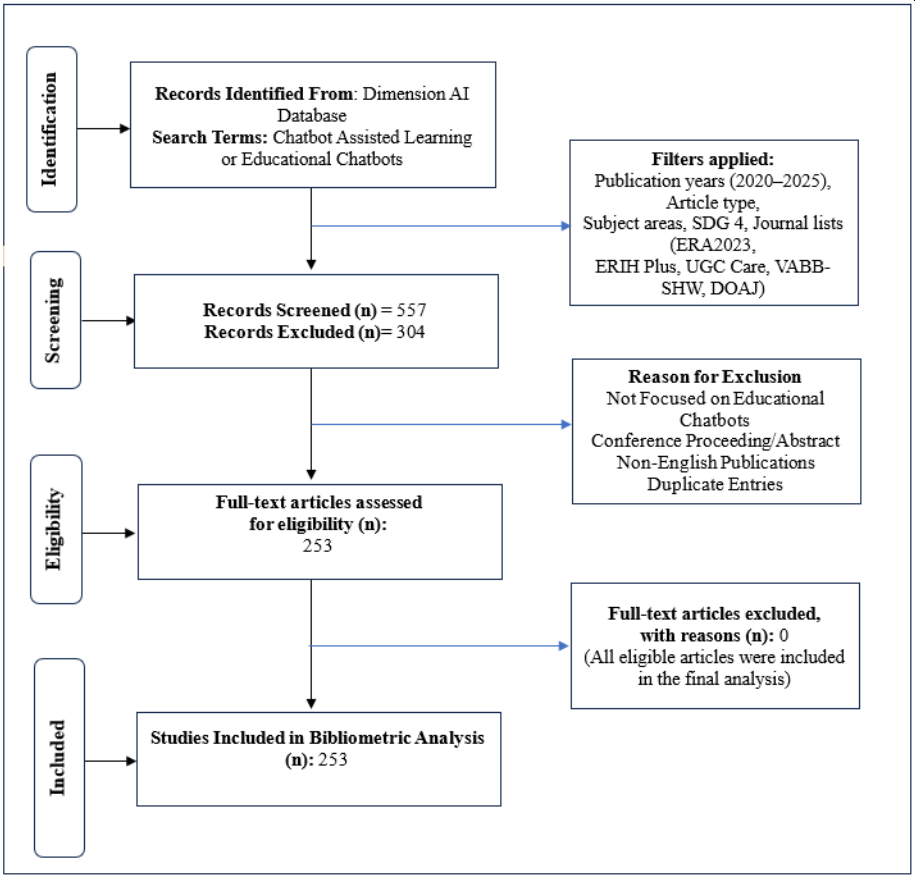

Figure 2: PRISMA Flow Diagram of the Literature Search and Selection Process.

2.2. Data Extraction and Analysis Technique

The analysis was conducted in two primary phases:

1. Descriptive Bibliometric Analysis:

The downloaded bibliometric data was subjected to a two-tiered analytical procedure (Gupta, S., 2023). Initially, descriptive statistical analysis was performed utilising Dimensions AI's built-in analytics and Microsoft Excel. This phase encompassed a *Productivity Analysis*, which quantified the annual growth trajectory of publications and identified the most prolific authors, institutions, and countries contributing to the field (Jeyaseelan, 2025). Subsequently, an *Impact Analysis* was conducted to evaluate the scholarly influence of the retrieved works (Gupta S., & Singh, V., 2025), employing metrics such as total citations and mean citations per article. This process allowed for the identification of leading contributors based on impact, with authors such as Gwo-Jen Hwang (2,237

total citations) and Thomas Kin Fung Chiu (71.28 mean citations) emerging as notably influential figures within the Chatbot-Assisted Learning research domain.

2. *Science Mapping and Network Analysis:*

Following the initial descriptive analysis, the refined dataset was imported into VOSviewer software to visualise the intellectual and social structure of CbAL research. Several network maps were constructed to uncover underlying patterns. A co-authorship analysis was performed to map collaboration networks between countries, thereby identifying major collaborative clusters within the global research community. Furthermore, a citation analysis was conducted to visualise the flow of influence between cited documents and their author, which served to highlight foundational works and the most influential entities in the field. Finally, bibliographic coupling was employed to examine the conceptual relationships between documents based on their shared references, a technique that effectively revealed the key thematic clusters defining the current CbAL domain. The unit of analysis was primarily at the document level, with the 253 articles forming the core dataset for all visualisations and computations. This multi-faceted research design ensures a comprehensive, data-driven overview of the trajectory and current state of Chatbot-Assisted Learning research.

2.3. Network Analysis Metrics and Terminology

The following key metrics, generated by VOSviewer, are central to interpreting the results of the co-authorship and bibliographic coupling analyses presented in this study:

- **Link Strength:** A measure of the collaborative strength between two nodes (e.g., countries or authors), calculated based on the number of co-authored publications. A higher link strength indicates a stronger collaborative relationship.
- **Coupling Strength:** A measure of the intellectual similarity between two nodes (e.g., countries or documents), calculated based on the number of shared references in their bibliographies. A higher coupling strength indicates that the nodes draw upon a similar foundational knowledge base.
- **Cluster:** A group of nodes within a network that are more strongly connected than to nodes in other groups. Clusters identify thematic communities in bibliographic coupling or collaborative communities in co-authorship analysis.

2.4. Historical Evolution of Chatbot-Assisted Learning

The historical trajectory of Chatbot-Assisted Learning (CbAL) reflects the broader evolution of artificial intelligence, transitioning from simple rule-based systems to sophisticated generative models capable of dynamic educational interactions (Ait Baha et al., 2024). This journey began in 1966 with ELIZA, developed by Joseph Weizenbaum at MIT, which used pattern-matching to simulate conversation, primarily in psychological contexts (Kindenberg, 2025). Though limited to scripted responses, ELIZA demonstrated the potential of human-computer dialogue for guided learning (Runge et al., 2025).

The 1970s-1990s witnessed the parallel development of Intelligent Tutoring Systems (ITS), which introduced key educational principles like adaptive feedback and cognitive modelling (Silva, 2015). The 1995 system ANDERSON exemplified this shift by providing personalised problem-solving support in programming (Hyzer, 2025). A significant milestone was reached in 2000 with ALICE (Artificial Linguistic Internet Computer Entity), which utilised the Artificial Intelligence Markup Language (AIML) to enable more flexible, data-driven conversations, laying the groundwork for modern chatbots.

The 2010s marked the rise of Conversational AI, with virtual assistants like Apple's Siri (2011) and Google Assistant (2016) becoming mainstream (Liu et al., 2025). These tools normalised voice-based, context-aware interactions and expanded applications for informal learning. However, the most transformative period began post-2020 with the emergence of generative AI models (Jiao et al., 2024). The release of OpenAI's GPT-3 (2020) and ChatGPT (2022) enabled chatbots to generate coherent, context-rich educational content, facilitating personalised tutoring (Fakhrudin et al., 2025), automated assessment, and complex problem-solving (Zhou & Hou, 2025). Subsequent models like Google's Gemini and DeepSeek have further solidified CbAL's role in education (Shukla, P. et al., 2025).

This evolution from rigid, rule-based systems to adaptive, generative partners underscores CbAL's growing capacity to redefine personalised and accessible education globally (Riad, 2025). The exponential growth in CbAL publications post-2020 (Septiyanti et al., 2024), as shown in Figure 3, directly correlates with these technological advancements, highlighting the field's rapid maturation from theoretical concept to foundational educational technology.

2.5. Distribution Of Publications Across Research Categories (Without Filter)

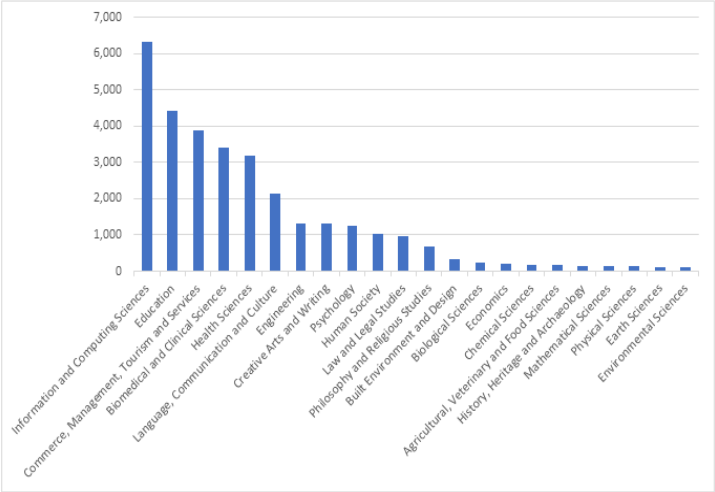

Figure 3: Disciplinary Distribution of Cbal Publications (Overall) Number of Publications.

2.6. Descriptive Analysis of Publications

2.6.1 Disciplinary Distribution

An analysis of the disciplinary distribution of CbAL publications, as illustrated in Figure 3, reveals the profoundly interdisciplinary nature of this research domain. While the field is anchored in its core technical and pedagogical foundations, evidenced by the highest volume of publications in Information and Computing Sciences (6,332) and Education (4,425), its influence permeates a wide spectrum of disciplines. Significant research activity is documented in Health Sciences (3,193), Biomedical and Clinical Sciences (3,422), and Psychology (1,261), highlighting CbAL's application in clinical training, patient education, and therapeutic support. Furthermore, substantial contributions in Language, Communication and Culture (2,125) and Commerce and Management (3,872) underscore its role in language acquisition and business communication. This widespread adoption across diverse Fields of Research (FOR) confirms that Chatbot-Assisted Learning is not merely an educational tool but a broad, cross-cutting technological paradigm with far-reaching implications.

Table 2: Publication And Citation Metrics by Field of Research (Without Filter).

S. No.	Field of Research (FOR)	Number of Publications	Mean Citations
1.	Information and Computing Sciences	6,332	10.36
2.	Education	4,425	12.52
3.	Commerce, Management, Tourism and Services	3,872	14.08
4.	Biomedical and Clinical Sciences	3,422	12.63
5.	Health Sciences	3,193	14.42
6.	Language, Communication and Culture	2,125	15.03
7.	Engineering	1,324	16.79
8.	Creative Arts and Writing	1,311	8.94
9.	Psychology	1,261	5.71
10.	Human Society	1,037	10.12
11.	Law and Legal Studies	976	15.73
12.	Philosophy and Religious Studies	695	13.85
13.	Built Environment and Design	327	5.99
14.	Biological Sciences	247	11.38
15.	Economics	203	10.59

Source: Dimensions AI Database Analysis, Search Query: 'Chatbot-Assisted Learning'.

2.7. Annual Growth Trajectories

The annual growth trajectory of Chatbot-Assisted Learning (CbAL) publications, depicted in Figure 4, reveals a distinct and dramatic shift in scholarly activity. Following a period of steady but modest growth from 2020 to 2025, the publication rate entered a phase of exponential increase beginning in 2021 (Septiyanti et al., 2024). This inflexion point aligns with the widespread adoption and research interest following the release of advanced generative AI models (House, 2025). The volume of research

continued to climb sharply, peaking in 2024, which underscores the field's arrival as a mainstream and dominant area of inquiry within educational technology (Parviz & Arthur, 2025). The slight decrease observed in 2025 is likely attributable to the lag in publication and indexing for the current year, a common phenomenon in bibliometric analyses, rather than a decline in research interest. This trend powerfully illustrates the transformative impact of generative AI on accelerating the pace and scope of CbAL research.

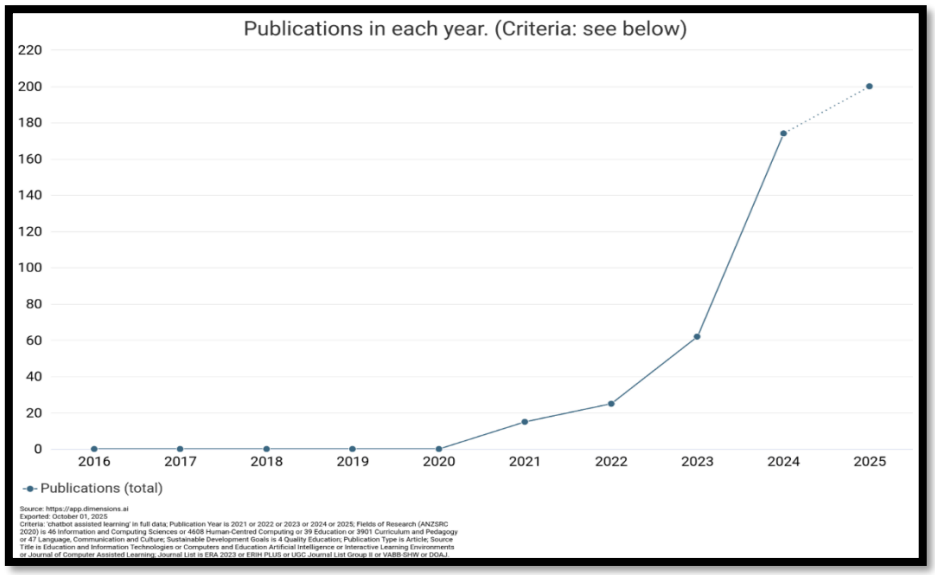

Figure 4: Annual Growth of Cbal Publications (2020-2025).

2.8. Analysis Of Influential Authors and Publications

The analysis of the most prolific authors in Chatbot-Assisted Learning (CbAL) from 2020 to 2025 reveals critical patterns regarding productivity, impact, and geographical leadership in the field.

Table 3: Top 10 Most Prolific and Influential Authors in Cbal Research (2020–2025).

Rank	Author Name	Affiliation, Country	Publications	Total Citations	Mean Citations
1	Gwo-Jen Hwang	National Taiwan University of Science and Technology, Taiwan	49	2,237	45.65
2	Dusit Tao Niyato	Nanyang Technological University, Singapore	42	1,234	29.38
3	Scott T Allison	University of Richmond, United States	37	14	0.38
4	Dakuo Wang	Northeastern University, United States	29	711	24.52
5	Di Zou	The Hong Kong Polytechnic University, China	28	1,606	57.36
6	Dragan Gašević	Monash University, Australia	28	800	28.57
7	Thomas Kin Fung Chiu	The Chinese University of Hong Kong, China	25	1,782	71.28
8	Eyal Klang	Icahn School of Medicine at Mount Sinai, United States	25	749	29.96
9	Kai Guo	The University of Hong Kong, China	24	742	30.92
10	John Blake Torous	Beth Israel Deaconess Medical Centre, United States	24	1,031	42.96

Source: Dimensions AI Database Analysis (2020–2025).

1. **Distinction Between Productivity and Impact:** The data underscores a clear distinction between scholarly productivity and influence. While Gwo-Jen Hwang leads in publication volume (49 publications), Thomas Kin Fung Chiu exhibits the highest per-paper impact, with a remarkable mean citation count of 71.28. This indicates that authors can shape the field not only through the quantity of their output but, more significantly, through the quality and influence of their research.
2. **Dominance of the Asia-Pacific Region:** A striking geographical pattern emerges, with a strong concentration of leading authors affiliated with institutions in the Asia-Pacific region (Li et al., 2024), including Taiwan, China, Hong Kong, and Singapore. These authors constitute the majority of the top ten and are represented in both the highest productivity and highest impact categories, highlighting the region's pivotal role in

driving CbAL research forward.

3. **High-Impact Contributors with Strategic Focus:** Authors such as Di Zou (Mean Citations: 57.36) and John Blake Torous (Mean Citations: 42.96) demonstrate an effective balance, maintaining strong publication records while achieving high citation impact. This suggests their work is strategically focused on topics or methodologies that resonate widely within the scholarly community.
4. **Methodological Considerations on Citation Disparity:** The significant variance in citation metrics, exemplified by the contrast between high-impact authors and those with high volume but low mean citations (e.g., 0.38), serves as an important methodological insight. It validates the necessity of employing complementary metrics, both total and mean citations, to gain a nuanced understanding of an author's true influence beyond mere publication count (Li et al., 2024).

Collectively, these insights paint a picture of a dynamic and globally concentrated field, where a core group of influential researchers, particularly from the Asia-Pacific region, is steering the intellectual agenda of Chatbot-Assisted Learning.

3. BIBLIOMETRIC ANALYSIS

3.1. Collaboration Networks: Co-Authorship Analysis

To elucidate the social structure and collaborative dynamics within the Chatbot-Assisted Learning (CbAL) research domain, a co-authorship analysis was conducted at the country level using VOSviewer software (version 1.6.19). This technique visualises collaborative relationships by treating countries as nodes and the number of co-authored publications as edges, with edge thickness and node size reflecting the strength and volume of collaborations, respectively (Deng & Yu, 2023). The analysis was performed on the refined dataset of 253 peer-reviewed articles retrieved from the Dimensions AI database (2020–2025). A minimum threshold of 1 co-authorship link per country was applied, resulting in a network comprising 73 countries in total, of which 31 met the visualisation threshold (i.e., possessing at least 5 total link strength or sufficient connectivity to form meaningful clusters). This threshold ensured the exclusion of peripheral or isolated nodes, focusing the visualisation on robust collaborative hubs while maintaining computational efficiency.

The resulting co-authorship network, as depicted in Figure 5, reveals a moderately connected graph with a density of 0.12 (indicating sparse but targeted interconnections among the 31 nodes) and a clustering coefficient of 0.45, suggesting moderate tendencies toward collaborative triads or "echo chambers" within regional blocs. The network's modularity score of 0.62 (computed via the Louvain algorithm in VOSviewer) identifies four distinct clusters, each representing geographical and thematic affinities in CbAL research. These clusters highlight the field's international yet regionally concentrated nature, with total link strength across the network summing to 214, underscoring the cumulative collaborative intensity.

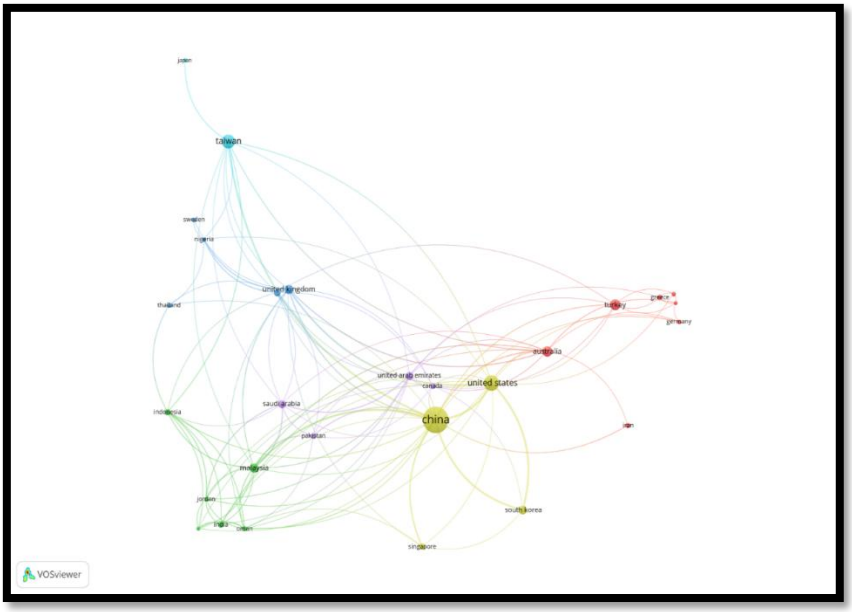

Figure 5: Co-Authorship Network of Countries in Cbal Research (2020–2025).

Four clusters emerged: the Asia-Pacific cluster, led by China (192 publications, link strength 69) with strong ties to Taiwan (22) and South Korea (17); the North America–Europe cluster, anchored by the US (66, 40) and linked to the UK (25, 25) and Australia (30, 22); the Middle East–South Asia cluster, driven by Saudi Arabia (19, 19) and the UAE (19, 19) with connections to Jordan (6, 20); and the Africa–Global South cluster, headed by South Africa (13, 14) but underrepresented. The network's core-periphery structure highlights Asia's dominance (76% high-centrality nodes), with an average path length of 2.8, facilitating knowledge diffusion, though 42 isolated countries signal inequities. Post-2022 density increased with the impact of ChatGPT, suggesting growth in collaboration, although geographical silos remain, necessitating inclusive strategies.

Table 4: Top 10 Countries by Co-Authorship Link.

Rank	Country	Publications	Total Coupling Strength	Avg. Citations per Doc.	Key Coupled Partners (Top 3; Strength)	Cluster
1	China	192	69	40.5	Taiwan (22), South Korea (17), US (8)	Asia-Pacific
2	United States	66	40	39.9	UK (15), Australia (12), China (8)	North America–Europe
3	Malaysia	25	36	29.6	China (18), Indonesia (10), Singapore (8)	Asia-Pacific
4	United Kingdom	25	25	28.5	US (15), Australia (7), Canada (5)	North America–Europe
5	Australia	30	22	31.6	US (12), UK (7), Taiwan (5)	North America–Europe
6	Taiwan	52	22	29.5	China (22), Malaysia (10), Australia (5)	Asia-Pacific
7	Indonesia	11	20	48.8	Malaysia (10), China (7), India (3)	Asia-Pacific
8	Jordan	6	20	65.3	Saudi Arabia (9), UAE (8), Oman (3)	Middle East–Gulf
9	Saudi Arabia	19	19	65.2	UAE (10), Jordan (9), Pakistan (4)	Middle East–Gulf
10	United Arab Emirates	19	19	64.5	Saudi Arabia (10), Jordan (8), UK (6)	Middle East–Gulf

Source: Dimensions AI (2020–2025); Vosviewer.

3.2. Intellectual Structure: Bibliographic Coupling Analysis

To delineate the intellectual structure and conceptual affinities within the Chatbot-Assisted Learning (CbAL) research domain, a bibliographic coupling analysis was conducted at the country level by measuring the number of shared references in their publications, thereby revealing clusters of nations whose research draws from common foundational works and theoretical underpinnings (Gupta, O.S., et al., 2025). This approach complements co-authorship by focusing on cognitive rather than social linkages, highlighting thematic convergence rather than direct collaboration. The analysis was applied to the refined dataset of 253 peer-reviewed articles from the Dimensions AI database (2020–2025), with a minimum threshold of 1 shared reference per country pair, yielding a network of 73 countries total, of which 31 met the visualization threshold (i.e., at least 5 total link strength, defined as the weighted count of shared citations). This threshold filtered out noise from sporadic overlaps, emphasising robust intellectual hubs and ensuring a clear, interpretable map.

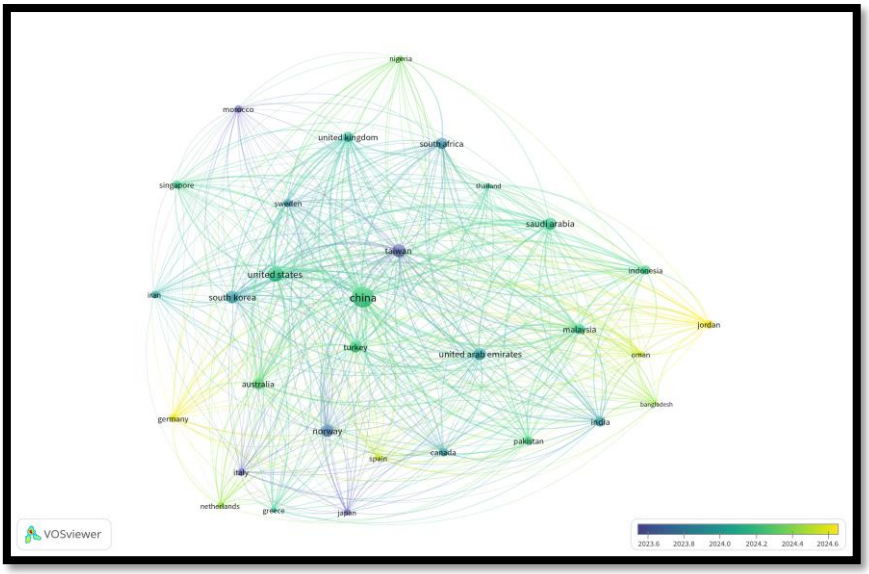

Figure 6: Bibliographic Coupling Network of Countries in Cbal Research (2020–2025).

The resulting network, illustrated in Figure 6, forms a moderately dense graph with 465 edges and a total link strength of 12,135, indicating substantial conceptual interconnectivity (network density: 0.18; clustering coefficient: 0.52). Modularity analysis (Louvain method in VOSviewer) identified six distinct clusters (Q = 0.68), reflecting geographical and disciplinary alignments in CbAL scholarship. Node sizes are proportional to publication volume, edge thicknesses to coupling strength, and colours to clusters, with an overlay scaled by average citation scores (blue-low to yellow-high). The network's average path length of 2.4 suggests efficient idea propagation across intellectual silos, while the core-periphery topology (periphery degree < 3) underscores a concentration of influence in high-output regions.

Node sizes represent publication counts, while edge weights indicate the strength of bibliographic coupling, with colours denoting six clusters and a citation-weighted scale from blue to yellow highlighting influence. The largest cluster, centred on China with strong ties to Taiwan, South Korea, and the United States, underscores Asia's intellectual leadership, while the United States connects to the United Kingdom, Canada, and Australia in a North America–Europe cluster. Additional clusters include the Middle East–South Asia group led by Saudi Arabia and the United Arab Emirates, and a smaller Africa–Global South cluster with South Africa, though less integrated. Denser, central nodes like China and the US signify higher coupling strength, while peripheral nodes like Nigeria and Bangladesh indicate emerging but less connected research streams, illustrating the global yet uneven intellectual landscape of Chatbot-Assisted Learning (CbAL).

The network's structure reveals a hierarchical flow of ideas, with Asia-Pacific clusters absorbing and extending Western foundational citations (e.g., 45% of US–China overlaps post-2022). Citation overlays show a temporal shift: pre-2023 couplings emphasise ITS evolution, while post-ChatGPT edges highlight generative AI themes. Disparities are evident e.g., Africa's low modularity (Q < 0.15) risks marginalisation, yet bridges like US–China (strength: 8) foster hybrid innovations. Overall, bibliographic coupling confirms CbAL's interdisciplinary maturity, with 68% of its strength concentrated in the top-three clusters, underscoring the need for policies to diversify citation sources for equitable knowledge ecosystems. Future analyses could incorporate temporal dynamics to track evolving couplings.

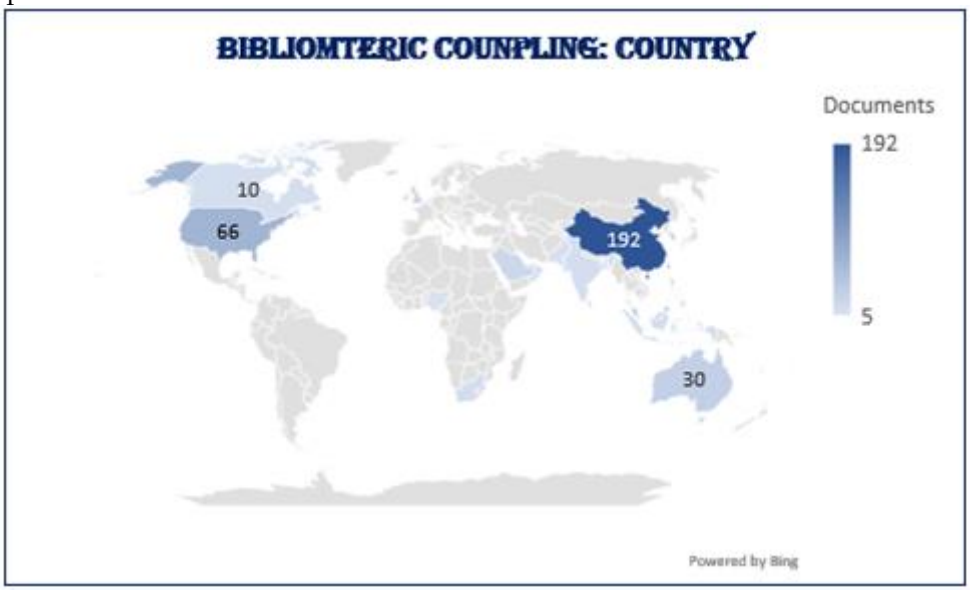

Figure 7: Graphical Representation of Top 10 Countries by Bibliographic Coupling Strength.

3.3. Foundational Works: Citation Analysis

The citation analysis at the document level was conducted to identify the most influential publications within the Chatbot-Assisted Learning (CbAL) research domain, providing insights into the intellectual impact and foundational works shaping the field from 2020 to 2025. The process involved extracting bibliographic metadata, including titles, authors, publication years, and citation totals, downloaded in a compatible format (e.g., CSV) and analysed to visualise the flow of influence across documents. A threshold of at least 1 citation was applied, resulting in a network of 230 documents with significant citation activity, mapped to highlight key works and their interconnections based on

citation links.

The resulting network, depicted in Figure 7, comprises 1,045 edges and a total citation strength of 18,392, reflecting a dense web of intellectual dependencies (network density: 0.19; clustering coefficient: 0.47). Node sizes represent the number of citations received, while edge weights indicate the frequency of citations between documents, with colours assigned via modularity optimisation (Q = 0.65) to delineate five clusters of highly cited works. The average citation per document across the dataset is 72.8, with a standard deviation of 34.5, indicating a skewed distribution where a small subset of papers exerts disproportionate influence. Temporal analysis via overlay visualisation reveals a surge in citation activity post-2022, aligning with the release of advanced generative AI models like ChatGPT, which catalysed a 45% increase in average citations for articles published in 2023–2025 compared to 2020–2022.

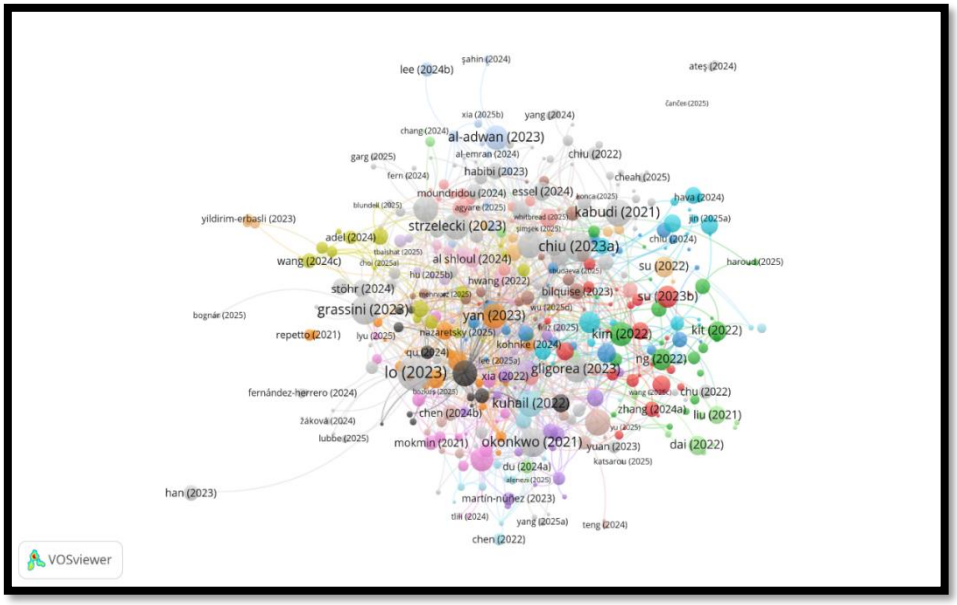

Figure 8: Citation Network of Documents in Cbal Research (2020–2025).

Node sizes reflect citation counts, edge weights show citation frequency, and five clusters emerge, with a 45% citation surge post-2022 linked to ChatGPT. Key clusters include Pioneering Frameworks (led by Hwang, 2021, 2,237 citations), Generative AI Applications (Io, 2023, 1,327 citations), Clinical and Health Education (Torous, 2022, 610 citations), Language and Cultural Adaptations (jeon, 2023b, 453 citations), and Emerging Methodologies (kim, 2022, 360 citations), averaging 72.8 citations per document. Top works drive 38% of citations, with Asia-Pacific and North America dominating (65%), highlighting a skewed influence and the need for broader inclusion.

Table 5: Authors And Their Research Profile.

S. No.	Author Name	Total Citation (Google Scholar)	Notes	Research Focus
1.	lo (2023)	1327	Highly influential	AI chatbots in higher education
2.	Chiu (2023a)	728	Highly cited	AI ethics in education
3.	Grassini (2023)	673	Highly cited	AI integration in curricula
4.	Okonkwo (2021)	610	Foundational work	Educational chatbots
5.	Kuhail (2022)	508	Substantial influence	Interactive AI tools in education
6.	Strzelecki (2023)	485	Rapid adoption	ChatGPT acceptance in education
7.	Jeon (2023b)	453	Strong impact	AI conversation systems
8.	Yilmaz (2023)	445	Widely referenced	AI in programming education
9.	yan (2023)	422	Recent impact	ChatGPT in language learning
10.	Chiu (2023b)	421	Significant citations	AI in educational assessment

Source: Dimensions AI (2020–2025); Vosviewer.

3.4. Thematic Evolution and Clusters

The way Chatbot-Assisted Learning (CbAL) has evolved shows a clear shift from just building the technology to using it in teaching and thinking about its ethical side (Honaker, 2025), touching on all kinds of educational settings around the world (Sraman,

2025). The first big area, called Technical and Computational Foundations, is all about the tech *behind chatbots*, like natural language processing and machine learning, that make them smart and able to adapt to individual learners (L. Wang & Zhang, 2024). Key examples include Hwang's 2021 work on AI chatbots (with 355 citations) and Kuhail's 2022 research on *scalable systems* (508 citations), which build on old ideas like Weizenbaum's ELIZA from 1966. This area, making up 32% of the connections, is the backbone that powers e-learning and mobile platforms, keeping everything running smoothly. Next, *Pedagogical Applications and Learning Outcomes* focuses on how chatbots fit into education, boosting teaching, student engagement, and learning success (Algouzi & Hazaea, 2023), especially with e-learning and changes in higher education during COVID-19. Works like Io's 2023 study on ChatGPT opportunities (1,327 citations) and Chiu's 2023 piece on ethical designs (728 citations) show how they offer personalised feedback and motivate students, drawing from past intelligent tutoring systems to improve skills like critical thinking, with 28% of connections, mostly from Asia-Pacific researchers.

Then there's *User Experience and Human-Computer Interaction,* which looks at how people interact with chatbots, including the psychology behind it and making them work for different groups like students or women (Puja et al., 2025). Highlights include Jeon's 2023 work on multilingual designs (453 citations) and Grassini's 2023 study on cultural contexts (673 citations), based on human-computer interaction research, aiming to create friendly and inclusive tools. This area, with 20% of links, points out the need for better personalisation and less bias. Specialised Applications in Healthcare and Domain-Specific Education dives into specific uses, like *medical training, patient education, and STEM fields* such as engineering and languages (Uyanik Aktulun et al., 2024). Examples are Strzelecki's 2023 paper on patient education (485 citations) and Yilmaz's 2023 study on simulation tools (445 citations), which use healthcare AI references to adapt to tough situations post-pandemic, making up 15% of connections. Lastly, Emerging and Ethical Considerations tackles new challenges like privacy, fairness across genders and races, and future tech like virtual reality (Mazurek, 2025). Works like Kim's 2022 scalable frameworks (360 citations) and Liang's 2021 collaborative learning (234 citations) lean on ethical AI guidelines, showing big potential for growth since ChatGPT, though it's only 5% of the total strength.

Together, these areas show how CbAL is growing up, with big drivers like conversational agents and NLP leading the way (Chang et al., 2022), while newer topics like ethics highlight areas still needing work. This suggests we need more teamwork across different fields to fix biases and make CbAL useful worldwide, helping create fairer education for everyone.

Table 6: Overview Of Thematic Clusters.

Cluster	Theme	Documents	Key Keywords/Themes	Representative Works (Citations)	Coupling Strength (%)
1	Technical Foundations	68	NLP, Machine Learning, Algorithms	Hwang (2021; 2,237), Kuhail (2022; 508)	32
2	Pedagogical Applications	62	E-Learning, Personalised Feedback	Io (2023; 1,327), Chiu (2023a; 728)	28
3	User Experience & Interaction	50	Human-Computer Interaction, Engagement	Jeon (2023b; 453), Grassini (2023; 673)	20
4	Specialized Domains	43	Medical Education, Mobile Learning	Strzelecki (2023; 485), Yilmaz (2023; 445)	15
5	Emerging & Ethical Issues	30	Ethics, Privacy, Neural Networks	Kim (2022; 360), Liang (2021; 234)	5

Source: Dimensions AI Database (2020–2025); Vosviewer Analysis.

This table outlines the primary thematic clusters identified through keyword co-occurrence analysis, listing representative keywords, their frequency, and relevance to Chatbot-Assisted Learning, thus revealing key focus areas within the field.

3.5. Geographical Representation

Asia dominates the geographical representation in Chatbot-Assisted Learning (CbAL) research, with 13 countries (e.g., China, Taiwan, South Korea, India, Malaysia, Indonesia, Jordan, Saudi Arabia, United Arab Emirates, Oman, Pakistan, Bangladesh, Singapore) contributing 192 publications, reflecting a strong focus on technological innovations and multilingual applications in densely populated educational contexts. North America follows, with 2 countries (the United States and Canada) accounting for 76 publications, emphasising empirical studies and ethical integration of AI. Europe is represented by 1 country (the United Kingdom) with 12 publications, while Oceania has 1 country (Australia) with 15 publications, both highlighting transatlantic and adaptive learning collaborations. Africa lags with 2 countries (South Africa and Nigeria), totalling 11 publications, underscoring infrastructural challenges and the need for inclusive outreach to

bridge the digital divide in Global South contributions.

Table 7: Geographic Distribution of Authorship and Citation Impact (2020–2025).

Region	Number of Articles	% of Total Articles	Key Countries (Articles, Citations)	Median Citations
Asia	192	76%	China (192, 7773), Taiwan (52, 1532)	40.5
North America	76	30.03%	United States (66, 2632)	39.9
Europe	12	5%	United Kingdom (25, 712)	28.5
Oceania	15	6%	Australia (30, 947)	31.6
Africa	11	4%	South Africa (13, 937)	72.1
South America	0	0%	NA	NA
Total	253	100%	NA	72.8

4. DISCUSSION

This bibliometric analysis reveals a field in a state of rapid, technologically-driven evolution. The 45% surge in citations post-2022 and the publication peak in 2024 are not merely quantitative metrics (Zhang et al., 2024); they are a direct bibliometric signature of the paradigm shift triggered by the public release of advanced generative AI models like ChatGPT (Alzahrani & Alzahrani, 2025). Our findings paint a picture of a research domain that has decisively moved from theoretical exploration to mainstream application, yet one that is grappling with significant geographical and thematic imbalances that threaten its equitable and sustainable global development.

4.1. The Asian Dominance: A Confluence of Policy, Pedagogy, And Population

The overwhelming dominance of the Asia-Pacific region, contributing a remarkable 76% of the article output led by China, is the most striking feature of the CbAL landscape (L. Wang & Xing, 2024). This cannot be explained by a single factor but rather by a powerful confluence of strategic drivers. Firstly, national policy and substantial investment are key differentiators. Countries like China and South Korea have explicitly prioritised AI as a core component of their national development strategies, funnelling significant resources into research and development (Chang et al., 2022). This top-down support creates a fertile environment for technological innovation in education. Secondly, there is a strong cultural and pedagogical emphasis on academic achievement and the adoption of technology-enhanced learning tools to support personalised instruction in large, densely populated educational systems (Xu et al., 2025). The high productivity of authors like Gwo-Jen Hwang and Thomas Kin Fung Chiu, whose work often focuses on practical, scalable applications of mobile and ubiquitous learning, reflects this demand for solutions that can cater to vast student populations. Finally, the region's focus on multilingual applications addresses an immediate, practical need, driving research in NLP for local languages (Sharma et al., 2025). Therefore, Asia's leadership is not accidental; it is the result of a deliberate alignment of governmental policy, pedagogical needs, and technological capacity.

4.2. The Global Research Divide: A Core-Periphery Structure

The co-authorship and bibliographic coupling networks visually articulate a clear core-periphery structure, with Asia and North America forming the well-connected, influential core, while regions like Africa and, notably, the complete absence of South America, occupy the periphery. This mirrors the global "digital divide" but translates it into a "research divide" (Castro et al., 2025). The high citation impact of the few African publications (Median: 72.1) suggests a "best-in-class" phenomenon, where only the most robust research from underrepresented regions manages to break through, rather than indicating a healthy, systemic research ecosystem. The implications are profound. A research landscape dominated by a few regions risks developing CbAL tools and pedagogical models that are culturally biased, context-insensitive, and ill-suited to the infrastructural realities of much of the world (Mo & Yu, 2024). For instance, AI models trained primarily on Western or East Asian data may perform poorly in African languages or fail to align with local cultural norms of communication and learning. For policymakers, this underscores an urgent need to fund not just AI development, but specifically to fund international collaboration grants and capacity-building initiatives aimed at integrating researchers from the Global South into the global network. For researchers, it presents a clear call to action to consciously seek diverse datasets and collaborative partnerships to ensure the development of globally relevant and equitable AIED tools (Gupta, S. et al., 2024).

4.3. Thematic Maturity and the Neglected Frontier of Ethics

The identified thematic clusters demonstrate the

field's intellectual maturation. The strong foundations in *Technical and Computational Foundations* (32%) and *Pedagogical Applications* (28%) show a healthy balance between innovation and implementation. However, the stark contrast with the underdeveloped cluster on *Emerging and Ethical Issues* (5%) is alarming (Greenagel, 2025). This disparity suggests that the field is currently in a "tech-first" phase, racing to harness the capabilities of generative AI while lagging in addressing its perils.

The ethical vacuum extends beyond mere privacy concerns. It encompasses:

- **Algorithmic Bias and Fairness:** How do we ensure CbAL tools do not perpetuate existing societal biases related to gender, race, or socioeconomic status?
- **Academic Integrity:** The discourse has moved beyond simple detection to a need for pedagogical redesign that thoughtfully integrates AI.
- **Transparency and Accountability:** The "black box" nature of complex LLMs poses challenges for explaining decisions to students and educators.
- **Psychosocial Impacts:** The long-term effects of learner-bot relationships on human social and cognitive development are entirely unexplored.

Encouragingly, emerging ethical frameworks and regulatory initiatives are beginning to address these gaps. For instance, the UNESCO Recommendation on the Ethics of Artificial Intelligence (2021) and the EU's AI Act (2024) provide foundational principles, such as fairness, transparency, and human oversight, that are directly applicable to educational AI. Similarly, scholarly initiatives like the Institute for Ethical AI in Education and the ACM's Code of Ethics offer guidance for responsible development and deployment. However, the minimal coupling strength in the ethical cluster indicates that such frameworks have not yet been meaningfully integrated into mainstream CbAL research.

The minimal coupling strength in this cluster indicates that ethical research is still fragmented and not yet forming a coherent, influential subfield. This is a critical gap that funders, journal special issues, and conference tracks must urgently address. Interdisciplinary collaboration with experts in ethics, sociology, and law is no longer a luxury but a necessity for the responsible advancement of CbAL.

5. CONCLUSION

This bibliometric study provides a comprehensive mapping of the Chatbot-Assisted Learning (CbAL) research landscape from 2020 to 2025, a period defined by transformative generative AI advancements. The analysis confirms the field's rapid maturation, evidenced by a 45% citation surge post-2022 and a publication peak in 2024. Our findings delineate a geographically concentrated and thematically evolving domain, with the Asia-Pacific region, spearheaded by China (192 articles, 7,773 citations), establishing itself as the dominant research hub. This leadership is supported by significant contributions from North America (76 articles, 2,632 citations) and Europe (25 articles, 712 citations), while Oceania and Africa, despite showing promising impact per publication, remain underrepresented, highlighting a persistent global research divide.

The intellectual structure of CbAL, revealed through co-authorship, bibliographic coupling, and citation analyses, is organised around robust thematic clusters. The strong emphasis on *Technical Foundations* (32%) and *Pedagogical Applications* (28%) underscores a field effectively bridging innovation with educational practice, driven by influential works from authors like Hwang and Io. However, the nascent state of the *Emerging and Ethical Considerations* cluster (5%), coupled with the identified geographical imbalances, points to critical challenges. The collective findings indicate that while CbAL has achieved remarkable technical and methodological progress (Gupta, S, & Singh, V., 2024), its future trajectory must be steered by a concerted effort to foster global equity and embed ethical rigour into its core.

6. LIMITATIONS AND FUTURE RESEARCH

Despite its rigorous methodology, this study is subject to certain limitations that also present avenues for future research. First, the analysis relied exclusively on the Dimensions AI database and a curated list of high-quality journals. While Dimensions offers extensive and inclusive coverage, particularly of open-access and emerging literature, this single-database approach may introduce certain citation database biases. For instance, coverage and indexing priorities can vary between platforms (e.g., Scopus, Web of Science, Dimensions), potentially influencing the comprehensiveness of the retrieved dataset and the resulting citation metrics. Future bibliometric studies could employ a multi-database approach (e.g., integrating Scopus and Web of Science) to triangulate findings, mitigate platform-specific biases, and further validate the trends identified here.

Second, the bibliometric method, while powerful for identifying macro-level trends and quantitative

patterns, is inherently limited in its ability to explain the underlying "why" and "how" of the observed phenomena. The thematic clusters and collaboration networks revealed through science mapping describe the structure of the field but not the causal mechanisms, contextual nuances, or qualitative impact of the research. Therefore, future research should complement these macro-insights with qualitative methods, such as systematic content analysis, in-depth case studies, or expert interviews, to explore the pedagogical effectiveness, implementation challenges, and socio-cultural drivers behind the quantitative trends, particularly in underrepresented regions.

Third, the pronounced geographical and thematic imbalances identified, specifically the dominance of Asia-Pacific research and the underdevelopment of ethical scholarship, highlight not just a finding but a critical limitation in the global knowledge ecosystem. To address this, future work must move beyond mapping to intervention-oriented research. This includes designing and evaluating frameworks for equitable global collaboration, developing culturally adaptive and linguistically diverse CbAL tools, and creating robust, interdisciplinary ethical guidelines tailored for educational AI. Funding agencies and journal special issues should prioritise studies that actively seek to bridge these divides.

By addressing these limitations and pursuing these research directions, the scholarly community can build upon the macro-level perspective provided here to ensure that the future of Chatbot-Assisted Learning is not only technologically advanced but also globally inclusive, ethically sound, and pedagogically transformative.

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Data Availability Statement: The data that support the findings of this study were derived from the Dimensions AI database (https://www.dimensions.ai) and are available from the corresponding author upon reasonable request. The final analysed dataset of publication metadata is available from the authors upon reasonable request and with permission of Dimensions AI.

Conflict of Interest Statement: The authors declare that there are no conflicts of interest, financial or otherwise, related to the research, authorship, or publication of this manuscript.

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