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MAPPING THE LANDSCAPE OF DIGITAL INQUIRY-BASED LEARNING: A BIBLIOMETRIC ANALYSIS

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Abstract:

This bibliometric analysis seeks to provide an in-depth examination of the academic landscape surrounding Digital Inquiry-Based Learning (DIBL). As digital technologies increasingly reshape educational practices, there is a pressing need for a comprehensive understanding of the research trends, key contributors, and thematic developments within this domain. The problem addressed by this study lies in the limited synthesis of the growing body of literature on DIBL, which hinders a nuanced understanding of its evolution and impact. To address this gap, we employed Scopus Analyzer and VOSviewer software to analyze a dataset comprising 1071 academic publications related to DIBL. The analysis identifies prevailing trends in publication volume, influential authors and institutions, and the key thematic clusters driving the field. Our findings indicate a marked increase in research output over recent years, with notable contributions from both the fields of educational technology and pedagogical research. The study further reveals distinct research clusters focused on the integration of digital tools into inquiry-based pedagogies, the effectiveness of such tools in enhancing student engagement, and their impact on learning outcomes. In conclusion, this bibliometric study provides a comprehensive mapping of the DIBL research landscape, offering critical insights into its current state and emerging directions. The findings contribute to a more informed understanding of how digital inquiry-based approaches are evolving and their implications for future educational practices.

Keywords:

Digital; Computerized; Inquiry-Based Learning

Introduction

Inquiry-based learning (IBL) has emerged as a prominent pedagogical approach in science education, driven by its potential to foster critical thinking (CT), problem-solving, and active learning among students. The integration of digital technologies has further amplified the effectiveness of IBL, enabling more dynamic and interactive learning experiences. Recent advancements in electronic learning environments have facilitated the structuring of IBL into distinct phases, forming what is often referred to as the inquiry cycle. This cycle typically includes stages such as Orientation, Conceptualization, Investigation, Conclusion, and Discussion, each contributing to a comprehensive learning process (Pedaste et al., 2015). The digital tools available today, ranging from virtual labs and simulations to augmented reality applications, have made it possible to implement IBL on a larger scale, providing teachers with innovative resources to enhance lesson planning and classroom activities (Sotiriou, Lazoudis, & Bogner, 2020)

The landscape of digital inquiry-based learning is continually evolving, with various models and frameworks being developed to optimize its implementation. For instance, web-based collaborative inquiry learning systems leverage the World Wide Web as a vast resource for knowledge exploration, allowing students to engage in collaborative problem-solving and knowledge construction through tools like concept maps (Chang, Sung, & Lee, 2003). Additionally, digital storytelling has been identified as an effective method to engage students in inquiry-based learning, particularly when integrated with digital museum collections, fostering self-directed exploration and creative outputs (Tsiviltidou & Vavoula, 2023). The role of digital libraries in supporting IBL in undergraduate science education further underscores the importance of aligning technological tools with pedagogical goals to create robust learning environments. As digital technologies continue to advance, the potential for deeper, more meaningful inquiry-based learning experiences expands, promising significant educational benefits.

Literature Review

The evolution of digital IBL has been marked by the proliferation of instructional strategies and technological tools aimed at enhancing critical thinking, scientific inquiry, and digital literacy in educational settings. (Sujatmika, Masykuri, Prayitno, & Sutarno, 2024) underscore the importance of CT skills in science education, particularly for counteracting misinformation. Inquiry models such as science, technology, engineering and Mathematics (STEM) education, problem-based learning, cooperative learning, and predict-observe-explain (POE) have proven effective for fostering these skills. Nevertheless, these models are inherently context-sensitive, necessitating adaptations that account for specific learning objectives, student characteristics, and subject matter. Furthermore, the interplay between digital tools and pedagogy is often mediated by educators' ability to customize these tools for diverse learner profiles, highlighting the importance of teacher preparedness and adaptability. (Brown et al., 2011) demonstrated the efficacy of digital simulations—integrating stages such as problem hypothesis, data collection, and induction—in developing inquiry skills among elementary students. However, limitations related to system design and interpersonal dynamics presented challenges. (Vo & Simmie, 2024) expanded on these findings, highlighting a prevailing emphasis on cognitive dimensions within scientific inquiry assessments while largely neglecting socio-cultural and ethical considerations. This points to an urgent need for more comprehensive evaluative frameworks that address these often-overlooked facets of inquiry learning, ensuring a more holistic approach to developing scientific competencies.

The advent of virtual laboratories (VLs) has redefined the traditional paradigms of inquiry-based learning by embedding digital tools at the core of modern pedagogical practices. (Reyes & Villanueva, 2024) documented a significant increase in the use of VLs during the COVID-19 pandemic, where these platforms transitioned from supplementary tools to primary vehicles for conducting scientific experiments. While VLs offer scalability and accessibility, they also present challenges, such as technological limitations and the difficulties associated with integrating them effectively into conventional curricula. Effective integration, as argued by (Tzovla & Kedraka, 2023), involves more than merely embedding digital content; it requires pedagogically sound strategies that incorporate technologies like SRIA to bridge the gap between theoretical knowledge and practical application. This also requires deliberate consideration of students' diverse learning needs, as the successful deployment of VLs demands differentiated instructional strategies that can cater to a range of cognitive abilities and preferences. Similarly, (Garofalo, 2024)) found that physical manipulation of three-dimensional models led to superior conceptual understanding compared to digital simulations alone, indicating the value of hands-on learning experiences in inquiry-based STEM education. The persistence of passive learning tendencies in some students, as observed by (Premthaisong & Srisawasdi, 2024), further underscores the need for a blended approach, integrating both physical and digital learning tools to create a rich, engaging learning experience that stimulates active participation and deeper comprehension. Taken together, these studies suggest that an optimal learning environment may require a carefully balanced integration of both physical and digital learning tools to cater to diverse learner needs and preferences, as well as robust scaffolding mechanisms to ensure meaningful engagement.

Digital inquiry-based learning has evolved substantially, fostering richer and more accessible educational experiences. It still faces notable challenges related to technological integration, scaffold design, assessment frameworks, and educator training. The development of comprehensive pedagogical models that synthesize digital and physical tools, address socio-cultural considerations, and empower educators with the necessary skills for facilitating advanced digital IBL environments remains a pressing priority. Addressing these gaps is essential for constructing an inclusive and effective framework for digital inquiry-based learning, thereby enhancing the quality of science education. Future research must prioritize strategies that merge traditional and digital approaches to foster an enriched, equitable learning experience for all students. Moreover, to move beyond the barriers that constrain the effectiveness of digital IBL, it is crucial to invest in professional development that equips educators with competencies in digital pedagogy, as well as institutional support systems that facilitate ongoing adaptation to technological advancements. Bridging the gap between digital potential and pedagogical practice is key to ensuring that all learners benefit from innovations in inquiry-based learning, thereby positioning education at the forefront of fostering critical, scientifically literate individuals.

Research Question

- What are the research trends in digital inquiry-based learning according to the year of publication?
- Who and how much has been published in the area with regard to the authors?
- Who are the top 10 authors based on citation by research?
- What are the popular keywords related to the study and have they evolved/changed during the last ten years?

- What are co-authorship countries' collaboration?

Methodology

Bibliometrics means the combination, management and investigation of bibliographic information obtained from publications which are scientific in nature (Alves, Borges, & De Nadae, 2021; Assyakur & Rosa, 2022; Verbeek, Debackere, Luwel, & Zimmermann, 2002). Along with general descriptive statistics, such as publishing journals, publication year and main author classification (Wu & Wu, 2017), it also comprises complex techniques such as document co-citation analysis. A successful literature review necessitates an iterative process involving the identification of appropriate keywords, a literature search, and a thorough analysis to build a comprehensive bibliography and yield dependable results (Fahimnia, Sarkis, & Davarzani, 2015). In light of this, the study sought to focus on top-tier publications, as they offer valuable insights into the theoretical perspectives shaping the evolution of the research domain. To ensure data reliability, the study relied on the Scopus database for data collection (Al-Khoury et al., 2022; di Stefano, Peteraf, & Veronay, 2010; Khiste & Paithankar, 2017). Moreover, in order to ensure the inclusion of high-quality publications, only articles published in rigorously peer-reviewed academic journals were considered, with a deliberate exclusion of books and lecture notes (Gu, Li, Wang, Yang, & Yu, 2019). Notably, Elsevier's Scopus, known for its extensive coverage, facilitated the collection of publications spanning from 2020 to December 2023 for subsequent analysis.

Data Search Strategy

The study adopted a systematic and methodologically rigorous screening process to establish the search parameters for retrieving relevant scholarly articles. Initially, the Scopus database was queried using the following search string: TITLE-ABS-KEY (digital OR computerized AND inquiry AND based AND learning OR inquiry-based AND learning), which resulted in an initial dataset comprising 1,099 articles. To enhance the specificity of the search results, the query was refined further by incorporating additional criteria:

> TITLE-ABS-KEY (digital OR computerized AND inquiry AND based AND learning OR inquiry-based AND learning) AND (LIMIT-TO (PUBYEAR, 1992) OR LIMIT-TO (PUBYEAR, 1993) OR LIMIT-TO (PUBYEAR, 1995) OR LIMIT-TO (PUBYEAR, 1996) OR LIMIT-TO (PUBYEAR, 1998) OR LIMIT-TO (PUBYEAR, 2000) OR LIMIT-TO (PUBYEAR, 2001) OR LIMIT-TO (PUBYEAR, 2002) OR LIMIT-TO (PUBYEAR, 2003) OR LIMIT-TO (PUBYEAR, 2004) OR LIMIT-TO (PUBYEAR, 2005) OR LIMIT-TO (PUBYEAR, 2006) OR LIMIT-TO (PUBYEAR, 2007) OR LIMIT-TO (PUBYEAR, 2008) OR LIMIT-TO (PUBYEAR, 2009) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2024)) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar")).

This refinement process culminated in a final set of 1,077 articles, which were subsequently employed for bibliometric analysis. As of November 2024, all pertinent articles indexed in the Scopus database related to digital and inquiry-based learning were systematically integrated into the study, thereby ensuring a comprehensive and current representation of the extant literature in the field.

The selection criteria for the literature search were rigorously defined to maintain methodological integrity. Specifically, only articles published in the English language between 1992 and 2024 were included, whereas articles published after 2024 or in languages other than English were excluded. The inclusion criteria stipulated that articles must be published in English within the specified timeframe of 1992 to 2024, while the exclusion criteria ruled out those published beyond 2024 or in non-English languages. This meticulous delineation of inclusion and exclusion criteria was instrumental in ensuring the robustness and reliability of the final dataset, facilitating a focused bibliometric analysis that upheld consistency in temporal scope and linguistic accessibility. Such a systematic approach was pivotal in maintaining rigor throughout the selection process, ultimately enhancing the validity and reliability of the ensuing analysis.

Data Analysis
VOSviewer is a user-friendly bibliometric analysis tool developed by Nees Jan van Eck and Ludo Waltman at Leiden University, Netherlands. It's widely used for visualizing and analyzing scientific literature by creating clear network visualizations, clustering related elements, and generating density maps. The software is highly versatile, allowing researchers to explore co-authorship, co-citation, and keyword co-occurrence networks, thereby gaining a deep understanding of research landscapes. Its interactive, continuously updated interface makes it easy to explore large datasets efficiently. VOSviewer's strength lies in its ability to compute bibliometric metrics, customize visualizations, and integrate with a variety of data sources, making it an essential tool for researchers looking to understand complex research topics in depth. What sets VOSviewer apart is its ability to transform complex bibliometric datasets into visually intuitive maps and charts. Specializing in network visualization, the software excels at clustering related items, analyzing keyword co-occurrence, and generating density maps, all presented through an easy-to-use interface that caters to both beginners and experienced researchers. The continuous development of VOSviewer ensures that it stays ahead of the curve, providing dynamic features like metrics computation and visualization customization. The tool's compatibility with different types of bibliometric data—like co-authorship and citation networks—makes it a versatile and invaluable resource for gaining meaningful insights into various research fields.

The datasets for this analysis, containing publication year, titles, author names, journal information, citations, and keywords, were collected from the Scopus database, covering the period from 2020 to December 2023. VOSviewer version 1.6.19 was used to analyze these datasets through clustering and mapping techniques. Instead of using traditional methods like Multidimensional Scaling (MDS), VOSviewer focuses on situating items in a low-dimensional space to ensure that the distances between items accurately reflect their similarity. VOSviewer shares some similarities with MDS, but where MDS calculates similarity metrics such as cosine and Jaccard indices, VOSviewer uses a more suitable method for normalizing co-occurrence frequencies, such as association strength (AS_{ij}), calculated using the formula:

$$ASij \text{ ¼ } Cij$$
$$Wiwj$$

which is "proportional to the ratio between on the one hand the observed number of cooccurrences of i and j and on the other hand the expected number of co-occurrences of i and j under the assumption that co-occurrences of i and j are statistically independent" (Van Eck and Waltman, 2010, p. 531). This approach allows for a more intuitive and accurate representation of relationships within bibliometric data.

Result and Finding

What Are The Research Trends In Digital Inquiry-Based Learning Studies According To The Year Of Publication?
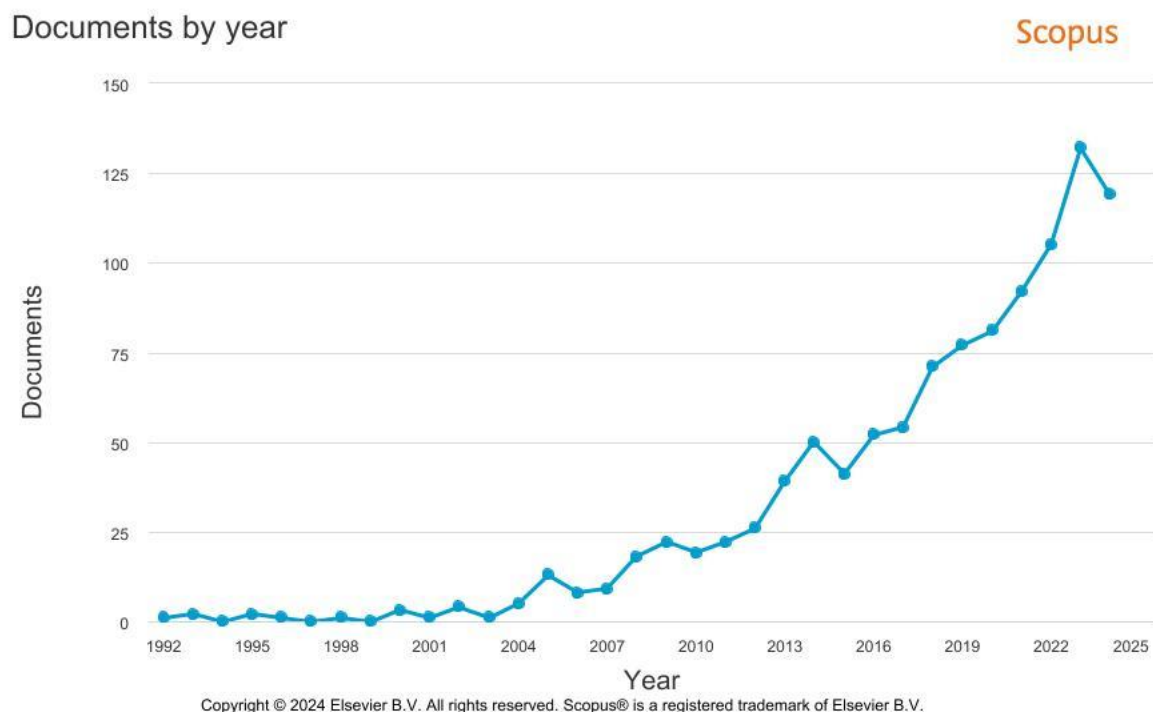
Figure 1: Plotting Document Publication By Years

The graph presents a comprehensive depiction of the progression of scholarly publications pertaining to digital inquiry-based learning, as indexed by the Scopus database, spanning a period of 33 years, from 1992 to 2024. The data elucidates a marked and sustained upward trend in the volume of academic output over this duration, reflecting an escalating level of scholarly interest and activity. Initially, the number of related publications was modest, starting at approximately five documents in the early 1990s. However, by 2024, this figure had grown significantly, exceeding 125 publications. Such growth signals a notable expansion in the research community's engagement with digital inquiry-based learning and the development of a broadening knowledge base in the domain. This progression has been particularly pronounced since the late 2000s, when the growth rate of publications indicates a near doubling every five years, on average. This accelerated increase underscores the recognition of digital inquiry-based learning as a critical focal point of research within the broader fields of educational

innovation and technology. Furthermore, the data highlights the maturation of this area as an active research domain, with increasingly nuanced exploration and theorization concerning its pedagogical applications and implications for teaching and learning processes.

The observed trajectory in publication volume suggests that digital inquiry-based learning has emerged as a significant locus of academic investigation, characterized by both a broadening scope of inquiry and deepening methodological sophistication. The increasing rate of publication further attests to the growing consensus among researchers regarding the relevance of digital inquiry-based approaches to contemporary educational practices. As such, this trend reveals both the expanding importance of this research area and its critical role in the transformation of modern pedagogical landscapes, providing a foundation for ongoing innovation and practical applications.

Who And How Much Has Been Published In The Area With Regard To The Authors?
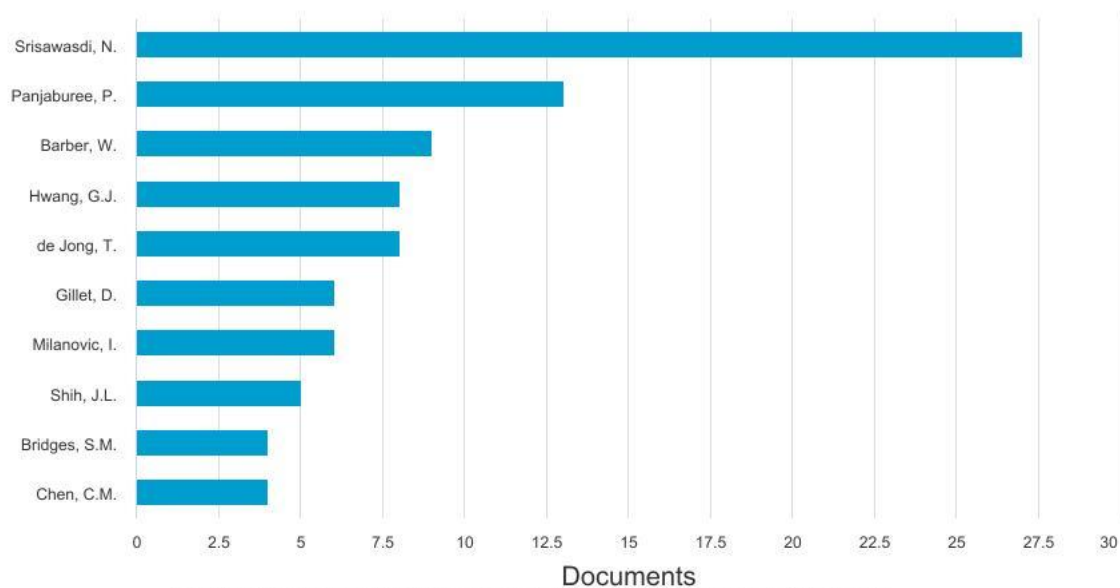
Figure 2: Plotting Document Publication By Author

The figure illustrates the publication counts for the top ten authors within the domain of digital inquiry-based learning, as cataloged by the Scopus database. Srisawasdi, N. stands out as the most prolific author, with an impressive total of approximately 27 publications. This high number of documents underscores their significant scholarly contributions and suggests an influential role in advancing research within this particular field. Following Srisawasdi, N., the next most prolific contributors are Panjauree, P. and Barber, W., with about 14 and 12 documents, respectively. While their publication counts are lower compared to Srisawasdi, N., their consistent output places them among the leading researchers in digital inquiry-based learning. Their contributions are vital to the broader discourse and indicate sustained academic engagement with the subject. The remaining authors on the list have fewer than ten publications each, highlighting a notable gap between the most prolific researchers and their peers. Though

these authors make valuable contributions to the body of literature, their output is comparatively modest, particularly in contrast to the top-ranked authors. This discrepancy in publication counts suggests that a small number of key individuals, especially Srisawasdi, N., are leading much of the research within this field. Consequently, while the field benefits from a range of contributors, the influence and volume of work appear concentrated among a few prominent figures, whose substantial output has likely played a pivotal role in defining and expanding the research landscape of digital inquiry-based learning.

Table 1: Author Document Contribution

Author	Number of documents	Percentage (%)
Srisawasdi, N.	27	2.52
Panjaburee, P.	13	1.21
Barber, W.	9	0.84
Hwang, G.J.	8	0.75
de Jong, T.	8	0.75
Gillet, D.	6	0.56
Milanovic, I.	6	0.56
Shih, J.L.	5	0.47
Bridges, S.M.	4	0.37
Chen, C.M.	4	0.37

The bibliometric analysis of authors contributing to the landscape of digital inquiry-based learning reveals a diverse set of leading researchers with varying levels of output. Among the authors, Srisawasdi, N. emerges as the most prolific, having contributed 27 documents, which represents 2.52% of the total literature covered in this analysis. This substantial contribution highlights the author's consistent focus on the field, positioning them as a key thought leader driving the body of knowledge in digital inquiry-based learning. Their significant output suggests that their research has likely addressed a range of aspects within this field, possibly contributing both foundational theories and practical methodologies for implementing digital inquiry in educational settings. Panjaburee, P., the second most contributing author with 13 documents (1.21%), along with other key contributors such as Barber, W. (9 documents, 0.84%), and Hwang, G. J. (8 documents, 0.75%), demonstrate that there is a relatively concentrated group of researchers who actively engage in this field. The moderate number of publications by these authors points to a diverse set of approaches and applications of digital inquiry-based learning across different educational contexts. For instance, Hwang, G. J., known for his expertise in mobile learning and digital pedagogies, adds a specialized perspective to the field. The collective contributions of these researchers help enrich the understanding of how digital tools and inquiry-based methodologies can intersect effectively in diverse learning environments.

The remaining authors, such as de Jong, T., Gillet, D., Milanovic, I., and others, contribute between 4 and 8 documents each, with individual contributions amounting to less than 1% of the total. Although their contributions are numerically fewer, these authors likely add niche perspectives or explore emerging themes within digital inquiry-based learning, thereby enriching the field with specialized insights or case studies. Their works may involve collaboration with other authors, further expanding the research network and bringing

interdisciplinary elements into the discourse. The relatively distributed contributions across multiple authors indicate a collaborative landscape, with a mix of consistent individual contributions and contributions that offer specialized or complementary insights into the broader framework of digital inquiry-based education.

Who Are The Top 10 Authors Based On Citation By Research?

The bibliometric analysis of the top 10 most-cited articles in the field of digital inquiry-based learning highlights key areas where technology and innovative pedagogical approaches are being integrated into education. The table reveals that project-based and inquiry-based learning methods dominate the discourse, with Kokotsaki et al.'s literature review on project-based learning (659 citations) being the most referenced. This suggests a broad interest in understanding and applying student-centered, inquiry-driven pedagogical techniques that promote critical thinking and active learning. Additionally, Ferri et al.'s article on online learning during emergencies (593 citations) reflects the increasing attention given to adapting educational practices to remote settings, particularly in the wake of global challenges such as the COVID-19 pandemic. Technology integration is another prevailing theme, with augmented reality (AR) and artificial intelligence (AI) playing a significant role in modernizing educational environments. The works of Dunleavy & Dede (436 citations) and Ibáñez & Delgado-Kloos (573 citations) emphasize the potential of AR to enhance engagement in STEM education, providing a deeper, experiential approach to understanding complex concepts. Yang's paper on AI education for young children (154 citations) further illustrates the expanding role of AI in early education, highlighting its benefits in curriculum design and development. These articles reflect a broader trend towards integrating emerging technologies into classrooms to foster interactive and adaptive learning experiences.

The influence of participatory research and mental health studies also appears in the list, as demonstrated by the articles by Chevalier & Buckles (235 citations) and Cheng et al. (154 citations). The focus on participatory action research aligns with the push for more inclusive, community-oriented educational research methods that allow for more engaged and collaborative inquiry processes. Cheng et al.'s work, assessing emotional distress through social media, points to the relevance of digital literacy and technology in not just facilitating learning but also understanding learners' mental health needs. Overall, the diverse range of topics covered by these highly cited works underscores the evolving landscape of digital inquiry-based learning, with a particular focus on utilizing technology to enhance both the efficacy and inclusivity of educational experiences.

Table 2: Publication And Citation Summary

Authors	Title	Year	Journal	Cited by
(Kokotsaki, Menzies, & Wiggins, 2016)	Project-based learning: A review of the literature	2016	Improving Schools	659
(Ferri, Grifoni, & Guzzo, 2020)	Online learning and emergency remote teaching: Opportunities and challenges in emergency situations	2020	Societies	593

(Ibáñez & Delgado-Kloos, 2018)	Augmented reality for STEM learning: A systematic review	2018	Computers and Education	573
(Dunleavy & Dede, 2014)	Augmented reality teaching and learning	2014	Handbook of Research on Educational Communications and Technology: Fourth Edition	436
(Chevalier & Buckles, 2019)	Participatory Action Research: Theory and Methods for Engaged Inquiry	2019	Participatory Action Research: Theory and Methods for Engaged Inquiry	235
(Wallace, Kupperman, Krajcik, & Soloway, 2000)	Science on the web: Students online in a sixth-grade classroom	2000	Journal of the Learning Sciences	203
(Barak & Dori, 2005)	Enhancing undergraduate students' chemistry understanding through project-based learning in an IT environment	2005	Science Education	195
(Shih, Chuang, & Hwang, 2010)	An inquiry-based mobile learning approach to enhancing social science learning effectiveness	2010	Educational Technology and Society	192
(Yang, 2022)	Artificial Intelligence education for young children: Why, what, and how in curriculum design and implementation	2022	Computers and Education: Artificial Intelligence	154
(Cheng, Li, Kwok, Zhu, & Yip, 2017)	Assessing suicide risk and emotional distress in Chinese social media: A text mining and machine learning study	2017	Journal of Medical Internet Research	154

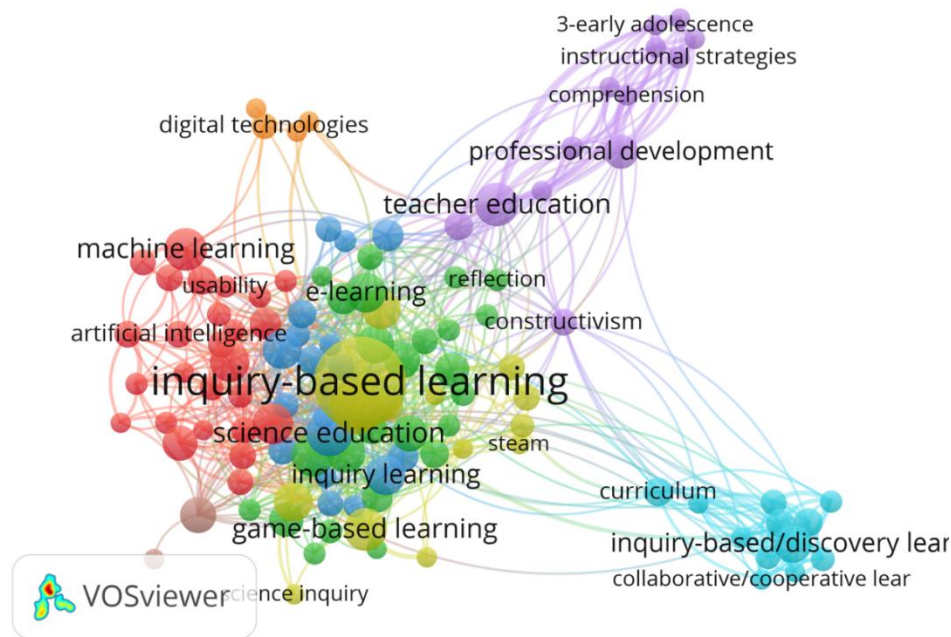*What Are The Popular Keywords Related To The Study?*

Figure 3: Network Visualization Map Of Keywords' Co-Occurrence

The bibliometric analysis of prevalent keywords extracted through Vosviewer reveals critical thematic trends and conceptual clusters within the field of digital inquiry-based learning. Notably, 'inquiry-based learning' (101 occurrences), alongside closely related concepts such as 'inquiry' (31 occurrences) and 'inquiry-based/discovery learning' (17 occurrences), stands out due to their substantial frequency and significant total link strength (110, 39, and 53, respectively). These metrics underscore the centrality of inquiry-driven methodologies in the current research discourse, highlighting their essential role in shaping pedagogical practices. The prominence of these themes suggests that much of the literature prioritizes exploring inquiry-based frameworks, emphasizing their vital significance in fostering active learning environments. Furthermore, the substantial occurrences and link strengths of 'collaborative learning' (16 occurrences, 29 link strength) and 'project-based learning' (11 occurrences, 20 link strength) underline the importance of collaborative and community-oriented instructional strategies that enhance the efficacy of inquiry-based learning.

The integration of technological elements is also a salient feature of the keyword analysis, with terms such as 'digital literacy' (17 occurrences) and 'digital technologies' (12 occurrences) indicating the pervasive role of technology in supporting pedagogical innovations. Keywords like 'artificial intelligence' (9 occurrences), 'augmented reality' (15 occurrences), and 'virtual reality' (9 occurrences) reflect the evolving incorporation of advanced technologies into educational practices, suggesting a transformative impact on the learning experience. The prevalence of terms such as 'blended learning' (18 occurrences, 24 link strength) and 'online learning' (22 occurrences, 37 link strength) further illustrates a growing trend towards hybridized learning models that effectively leverage digital platforms to enhance inquiry-based learning processes. Collectively, these technological components—underscored by 'technology-enhanced learning' (8 occurrences, 16 link strength)—point to the essential role of

digital tools in fostering interactive and dynamic educational environments that align with contemporary learning needs.

Moreover, there is a considerable emphasis on 'teacher education' (23 occurrences, 56 link strength) and 'professional development' (14 occurrences, 37 link strength), underscoring the necessity of preparing educators to competently adopt and implement digital inquiry-based learning methodologies. The frequent occurrence of terms like 'assessment' (12 occurrences, 18 link strength) and 'instructional design' (7 occurrences, 10 link strength) highlights the imperative of systematically evaluating learning outcomes and designing curricula that support these evolving pedagogical practices. Additionally, the repeated mention of 'engagement' (8 occurrences, 15 link strength) and 'motivation' (8 occurrences, 13 link strength) emphasizes the critical need to sustain student interest and active participation, particularly within digitally mediated learning environments. This focus on both educator readiness and learner engagement underscores the necessity of cultivating a comprehensive educational ecosystem that supports the effective implementation of inquiry-based learning, ultimately enhancing both teaching practices and learning outcomes.

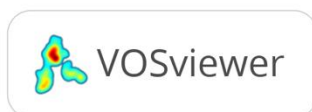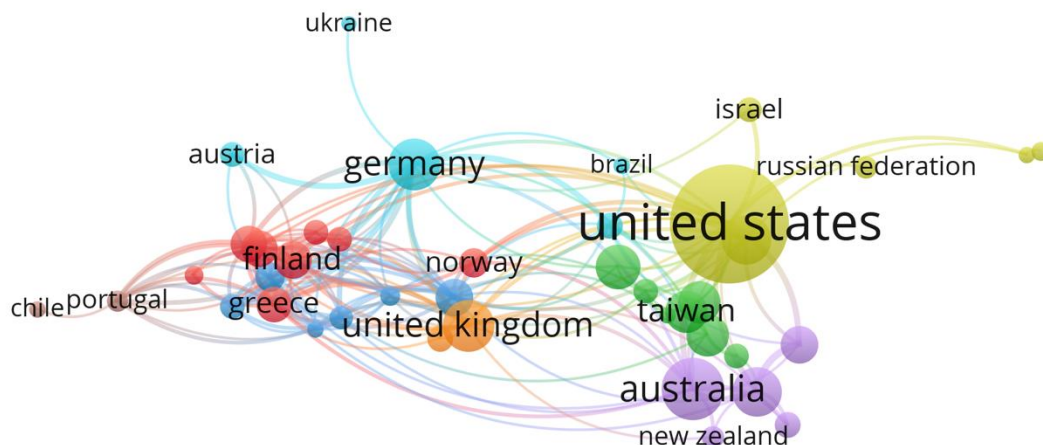## *What Are Co-Authorship Countries' Collaboration?*

Figure 4: Network Visualization Map Of Co-Authorship Countries' Collaboration

The data reveals a significant global distribution in the collaboration on Digital Inquiry-Based Learning (DIBL) research, with some countries leading in terms of document contributions and citations. The United States stands out with 280 documents and 4,266 citations, the highest in both categories and a relatively strong total link strength of 48. This suggests that the U.S. plays a central role in DIBL research and has strong collaborative ties with other countries. Similarly, Australia also shows high activity, contributing 78 documents with 958 citations and a total link strength of 27, indicating substantial involvement in this field, though not as dominant as the U.S. on the citation front. Countries like the United Kingdom (54 documents, 1,441 citations) and Germany (54 documents, 479 citations) also display robust contributions, albeit with a more moderate citation count compared to the U.S. and Australia. The United Kingdom,

with its high citation count (1,441), suggests that its research is widely referenced in the academic community, making it a key player in advancing DIBL scholarship. Similarly, Germany's relatively high total link strength (52) indicates strong collaboration with other nations, reflecting a well-connected research network. On the other hand, countries such as Belgium, Brazil, and Chile contribute fewer documents but still demonstrate notable citation impacts relative to their output, suggesting that their research, while limited in quantity, may hold high academic value.

On the lower end, countries like the Philippines, Ukraine, and Slovakia show minimal contributions (ranging from 5 to 7 documents), and their citation counts are quite low, indicating that these regions may have a smaller footprint in the global DIBL research network. However, countries like Singapore and Taiwan, despite fewer documents (14 and 37, respectively), show stronger citation counts, particularly Singapore, with 344 citations, reflecting an emerging presence in the field. The total link strength also varies widely, with countries like Estonia (31), Greece (35), and the Netherlands (37) demonstrating stronger collaborative networks, underscoring their roles in fostering international academic partnerships within the DIBL research landscape.

Conclusion

The research trends in digital inquiry-based learning have demonstrated a clear upward trajectory over the past three decades. Initially, the number of publications was low, but starting from the late 2000s, a significant surge in scholarly output is evident, with a near doubling of publications every five years. By 2024, the number of publications has surpassed 125 annually, highlighting the growing importance and recognition of digital inquiry-based learning as a pivotal area of educational research. This growth indicates that digital inquiry-based learning has evolved into a significant research domain, reflecting a broadening scope and increased sophistication in its study. The continuous rise in publications signifies its critical role in shaping modern pedagogical frameworks, with an emphasis on innovative digital tools and methodologies in teaching and learning. As for the authorship landscape, a small group of researchers dominates the field, with Srisawasdi emerging as the most prolific contributor, having published 27 documents. Other notable contributors include Panjaburee and Barber, with 13 and 9 publications respectively. While the remaining authors have smaller contributions, their work enriches the domain with specialized insights or case studies. This concentration of output among a few key figures, along with the continued participation of other scholars, suggests that the field is driven by a core set of researchers whose work significantly shapes the development and application of digital inquiry-based learning. The presence of a collaborative research environment is also evident, as multiple authors contribute across a variety of themes and perspectives, expanding the knowledge base with interdisciplinary and evolving approaches to digital inquiry in education.

The bibliometric analysis of keywords within digital inquiry-based learning underscores the prominence of inquiry-driven pedagogical frameworks in current educational research. Central terms such as "inquiry-based learning," "inquiry," and "discovery learning" reflect their foundational role in shaping teaching methodologies that prioritize student exploration and active learning. The frequent co-occurrence of "collaborative learning" and "project-based learning" further suggests a shift towards community-oriented strategies that complement inquiry-based approaches, enhancing student engagement and learning outcomes. Additionally, the inclusion of technological terms such as "digital literacy," "artificial

intelligence," and "virtual reality" emphasizes the increasing integration of digital tools in educational contexts, supporting more interactive and dynamic learning environments. The widespread use of "blended learning" and "online learning" further reflects a growing trend towards hybrid models that leverage digital platforms to facilitate inquiry-based processes, meeting the demands of contemporary educational landscapes.

The global collaboration in digital inquiry-based learning research reveals significant contributions from a range of countries, with the United States at the forefront, both in terms of document output and citation impact. Other countries, including Australia, the United Kingdom, and Germany, exhibit strong participation in the field, with notable contributions to the scholarly discourse. The United Kingdom, in particular, stands out due to its high citation counts, suggesting the widespread academic influence of its research. Similarly, Germany's strong collaborative network, as indicated by its high link strength, points to its active engagement in international research partnerships. While countries like Belgium, Brazil, and Chile contribute fewer documents, their research holds substantial academic value, as evidenced by relatively high citation metrics. In contrast, countries with fewer contributions, such as the Philippines and Ukraine, show limited engagement in the research network, though emerging scholarship from regions like Singapore and Taiwan indicates growing involvement in the field.

Acknowledgements

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