

Bibliometric Review of Artificial Intelligence in Project-Based Learning: Trends and Gaps in Social Sciences, Arts, and Humanities

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ABSTRACT

Purpose – The rapid development of Artificial Intelligence (AI) has significantly transformed various aspects of human life, particularly in education. This study aims to examine trends in the use of AI within Project-Based Learning (PjBL) strategies, specifically in the context of Social, Arts, and Humanities topics, over the period of 2014–2024.

Method – This study is a bibliometric review. The authors collected relevant research data from the Scopus database using the keywords ("artificial intelligence" OR "AI") AND ("project-based learning" OR "PjBL") AND ("education" OR "educational"), which were then analyzed using VOSviewer software version 1.6.20. At least 120 articles were gathered, and after article extraction, 41 articles were selected for analysis in this study.

Findings – The bibliometric review provides a comprehensive understanding of the current state of research on PjBL and AI. While significant progress has been made through interdisciplinary collaborations and high-impact publications, addressing the identified gaps in ethics, global integration, and inclusivity is crucial for realizing the full potential of AI in education. These efforts will enable the development of innovative, ethical, and globally relevant solutions to educational challenges.

Research Implications – This research enriches the discourse on educational innovation through a bibliometric review, highlighting the need for interdisciplinary collaboration to integrate AI in PBL. It emphasizes partnerships among computer scientists, educators, and social science experts to create culturally sensitive AI systems that enhance learning while addressing ethical concerns. The findings provide guidance for educators, researchers, and policymakers to ensure equitable and context-aware AI applications in education, benefiting all fields of knowledge.

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Introduction

Artificial Intelligence (AI) has currently developed quite rapidly in all lines of human life. In the education sector, AI has an impact on how knowledge is produced, distributed, and utilized. One of the most promising uses of AI is in Project-Based Learning (PBL). It is a method designed to put students as the main character, with their main activities being teamwork and actual problem-solving. Integrating AI into the teaching environment, teachers will be able to effectively improve the level of personalization, engagement, and quality of learning.

Despite the increasing use of artificial intelligence (AI) in education, the literature suggests that we have achieved the sustainable development of project-based learning (PjBL) in such a context is difficult due to challenges such as the diversity of disciplines in the social sciences and humanities, ethical and cultural sensitivities that interfere with the integration of AI tools, and the lack of interdisciplinary cooperation among current studies. The study aims to address these shortcomings through targeted bibliometric analysis that will identify trends, evaluate gaps, and propose pathways to effectively utilize AI within the discipline-tailored PBL framework.

As existing research has shown, AI tools have a clear role in streamlining processes and giving instantaneous feedback, for example, in updating project workflows with standup-grade AI-graded standups (Menezes et al., 2024). On the other hand, research into online PBL educational systems using AI. Ito et al. (2021) illustrates well how technology can support learning in remote or hybrid environments. But confronting such challenges unique to the fields of social sciences and humanities, which often center on critical thinking, ethical reasoning, and cultural context, offers both impediments and opportunities for AI integration.

Bibliometric analyses represent an important method for exploring the landscape of research, uncovering trends such as the growing popularity of AI tools used for collaborative learning and the emphasis on automation in feedback delivery. Some gaps emerging from the review include a lack of focus on the impact of culture and context in integrating AI and limited investigation into disciplines outside STEM. Such findings underline the relevance of this work, as this particular paper aims to fill these gaps by analyzing the specificities and needs of social sciences, arts, and humanities disciplines in the context of AI-integrated Project Based Learning models.

Previous bibliometric studies in STEM domains have shed light on how AI engenders innovation and accelerates skill acquisition. However, the interplay between AI, PBL, and social sciences is still only weakly addressed, as demonstrated by a few bibliometric reviews focusing on these fields. For example studies such as Heilala et al. (2023) have discussed briefly how AI could fit into heutagogical frameworks, but they did not critically reflect on specific approaches to heutagogy and their practical applications in the social

sciences. Similarly, Menezes et al. (2024) focused on AI-powered feedback systems but lacked exploration of their responsiveness to domains that demand subtle interpretative analytics. These are voids that necessitate a focused investigation into intersections of AI-PBL relevant to these fields (Heilala et al., 2023; Menezes et al., 2024).

This study fills this gap with the bibliometric analysis of AI applications to PBL, especially focusing on their applications in social sciences, arts and humanities. The analysis includes an examination of publication trends, prolific authors, institutional contributions, and thematic areas of focus. This study aims to identify the focal areas of interest while discovering the gaps in the literature that would not have been identified without the use of bibliographic data from Scopus and other databases.

Moreover, this investigation elaborates on the approaches in which AI can reinforce PBL's epistemological and methodological foundations beyond STEM. In contrast to STEM disciplines, which typically favor quantitative precision and algorithmic problem solving, non-STEM disciplines demand interpretative analysis, ethical reasoning, and cultural contextualization. These types of needs compel AI systems to operate within more liquid, dynamic, subjective, and nuanced frameworks, allowing us to connect more meaningfully to the humanistic and social dimensions of social sciences, arts, and humanities. Given that sociological and humanities-oriented fields have a greater emphasis on interpretative/context-sensitive methodologies, such research is not only relevant but necessary for understanding the deployment of generative AI systems. And here, the integration of heutagogical attunement with AIs we've been discussing suggests pathways for creating environments that are respectful of those nuances in depth.

By means of a comprehensive bibliometric review, our research is able to contribute to the general discourse around educational innovation as a whole. At the same time, it demonstrates that interdisciplinary approaches to PBL are needed if AI is ever going to reflect more than just technological developments in terms of culturally sensitive and contextual adaptation. Therefore, it proposes co-operation between those who have studied computer science, education experts, or professionals dealing with humanities subjects as well as social sciences. Only in this way can AI systems be designed that are culturally sensitive and relevant to context. They can also represent the rational potential of all sides to a question, allowing increasingly imitative technological resources to be. These approaches are an effort to synthesize technological advancements into a cultural and humanistic outlook, ensuring that AI tools not only improve outcomes for learning but also pay attention to ethical interpretive dimensions of non-STEM disciplines. The aim of this research is to provide guides that can assist educators, researchers, and administrators in implementing AI into education with a view towards both equity and context. We hope by doing so to ensure all benefits of technological progress redound on ever-wider areas of knowledge.

Methods

The bibliometric analysis applied in this study contributes to clarifying the relationship between the field of education and the recent advances in artificial intelligence in the context of project-based learning. The methodology consisted of a systematic review of 41 articles retrieved from the Scopus database. The selection criteria were that they were using certain keywords: ("artificial intelligence" OR "AI") AND ("project-based learning" OR "PjBL") AND ("education" OR "educational"). The identified records were then exported into CSV and RIS file formats. These files will allow further analysis and visualization, performed using VOSviewer software. This ensured a thorough analysis of trends, patterns, and relationships found in the extant literature concerning the topic (Donthu et al., 2021; Sahni & Singh Kaurav, 2023).

The data presented in this study is regarding the number of publications per year and on a per-country basis and distribution of the articles on the same subject, for investigation of contemporary standards in research. Then the researcher used NVivo software/program for the organization of the data to be able to present Overlay Visualization/mapping by Keywords as to be able to analyze them as they did. It is used to find the gap in this study against previous studies by analyzing the importance of keywords in Scopus articles. Related domains that had overlapping keywords in the artifacts were also visualized using the Density Visualization technique (Segura-Robles et al., 2020; Susilowati et al., 2024).

Result

1. Search Keyword

To include high-quality articles, this study conducted an extensive search of Scopus academic databases. The search utilized a Boolean-optimized search string ("artificial intelligence" OR "AI") AND ("project based learning" OR "PjBL") AND ("education" OR "educational"). Only articles from international journals published between 2014 and 2024 were considered, ensuring relevance to recent developments.

2. Data Extraction Strategy

During the first step of searching in the literature, it was found that the articles were published over a period from 2014 to 2024, a period of ten years. Initially, 120 articles meeting the defined keywords criteria were retrieved in the first search. Then a systematic search strategy was executed to critique all articles that did not meet the determined inclusion criteria. The outcome of this screening, highlighting the number of articles retained versus rejected, is clearly described and summarized in Table 1.

Table 1. Criteria of Screening

Search Screening	Number of Articles
Non-English Manuscript	1
Book Source Type	31
Review Article/Conference Source	12
Article in Press	9
Non-Social Science, Art and Humanities Topic	26
Total	79

Determinants of article inclusion and exclusion from the screening process resulted in 76 articles of the 120 identified during the literature search being excluded due to them failing to meet the predefined inclusion criteria. Therefore, the other 44 articles complying with all the above-mentioned requisites were included for the final analysis. To give a clearer picture of the filtering results and how the dataset was refined, we provide a detailed comparison of the data matrix showing how articles were distributed before and after screening in Table 2.

Table 2. Matrix Data Comparison

Matrix Data	Initial Search	Refinement Search
Keyword	artificial intelligence, project based learning, education	artificial intelligence, project based learning, education
Publication year	2014-2024	2016-2024
Paper	120	41
Total Citation	431	299
h-index	11	9

Subsequently, an in-depth analysis of the 41 selected articles was conducted to identify those with the highest citation counts, reflecting their impact and influence within the field. The analysis revealed that 10 articles emerged as the most frequently cited, signifying their prominence in shaping the research discourse. The detailed citation metrics for these articles are systematically presented in Table 3.

Table 3. Top 10 most cited paper

Year	Author	Title	Publication	Cites
2023	Ng D.T.K.; Lee M.; Tan R.J.Y.; Hu X.; Downie J.S.; Chu S.K.W.	A Review of AI Teaching and Learning from 2000 to 2020	Education and Information Technologies	87
2023	Kong S.-C.; Cheung W.M.-Y.; Tsang O.	Evaluating an Artificial Intelligence Literacy Programme for Empowering and Developing Concepts, literacy and Ethical Awareness in Senior Secondary Students	Education and Information Technologies	33

Year	Author	Title	Publication	Cites
2021	Kahn K.; Winters N.	Constructionism and AI: A History and Possible Futures	British Journal of Educational Technology	32
2020	Martín Nájuez J.L.; Lantada A.D.	Artificial intelligence aided engineering education: State of the Art, Potentials and Challenges	International Journal of Engineering Education	26
2019	Van BRUMMELEN J.; Shen J.H.; Patton E.W.	The Popstar, the Poet, And the Grinch: Relating Artificial Intelligence to the Computational Thinking Framework with Block-Based Coding	Proceedings of International Conference on Computational Thinking Education Proceedings - 2021 3rd International Conference on	23
2021	Zhou X.; Tong Y.; Lan X.; Zheng K.; Zhan Z.	AI Education in Massive Open Online Courses: A Content Analysis	Computer Science and Technologies in Education, CSTE 2021	16
2024	Ng D.T.K.; Su J.; Chu S.K.W.	Fostering Secondary School Students' AI Literacy Through Making AI-Driven Recycling Bins A Systematic Review of AI Education In K-12 Classrooms	Education and Information Technologies Computers and	14
2024	Lee S.J.; Kwon K.	From 2018 to 2023: Topics, Strategies, and Learning Outcomes	Education: Artificial Intelligence World Transactions on	12
2022	Ghani A.	Engineering Education at the Age of Industry 5.0 - Higher Education at the Crossroads	Engineering and Technology Education Proceedings of the 23rd International Conference on	10
2021	Ito T.; Tanaka M.S.; Shin M.; Miyazaki K.	The Online PJBL (Project-Based Learning) Education System Using AI (Artificial Intelligence)	Engineering and Product Design Education, E and PDE 2021	9

Furthermore, a look at the most highly cited top 10 articles demonstrates the key role that broad, interdisciplinary research plays in shaping the field. The majority of the

well-cited publications were published between 2019 and 2023, which is a clear sign of the rapid development both in artificial intelligence technologies and in its impacts on education. We explore these issues based on the findings of these studies, highlighting the importance of AI literacy, ethical measures, and field-specific applications, further reinforcing the demand for a theoretical underpinning and methods of practice. Concentration of important research in synergistic areas of the high-tech space creates the need for broader, diverse voices from underrepresented backgrounds to be part of the equation in order to ensure equity and global relevance in AI outcomes. Through greater international and interdisciplinary-oriented collaboration, the discipline can ascend to address educational challenges more effectively and use AI for generating revolutionary and innovative learning experiences.

3. Compiling Data Stastictic by Year and Country

A manual content analysis was performed using Microsoft Excel software on the primary dataset that included 41 articles saved in CSV format. The subsequent Biblioshiny provided important statistics, such as patterns of publication over time and numbers of research publications per country. These results reflect the temporal dynamics of the scientific frontier as well as the international contributions in the field of artificial intelligence in education and project-based learning, and reveal the major leading countries that have contributed to the development of this area. This wide-reaching statistical summary is an essential basis for further, detailed bibliometric evaluation and discussion.

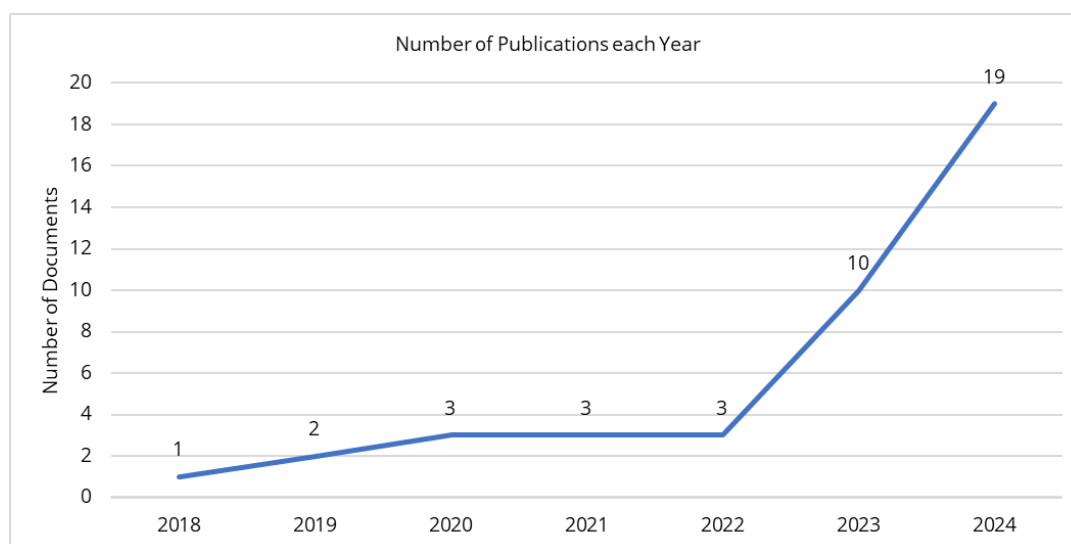


Figure 1. Number of Publication by Year

Figure 1 shows the development of a project-based learning research program as revealed by high-level analyses of publication trends over time. Beginning with a single publication in 2018, the field experienced incremental growth, resulting in two in 2019 and three annually from 2020 to 2022. This consistent climb demonstrates the increasing academic and practical interest in embedding artificial intelligence into pedagogical

practices. The overall number of publications has remained consistent in recent years, a sign that this body of scholarship has stabilized, with a developing area of study claiming a stable amount of attention and contributions from the scholar community.

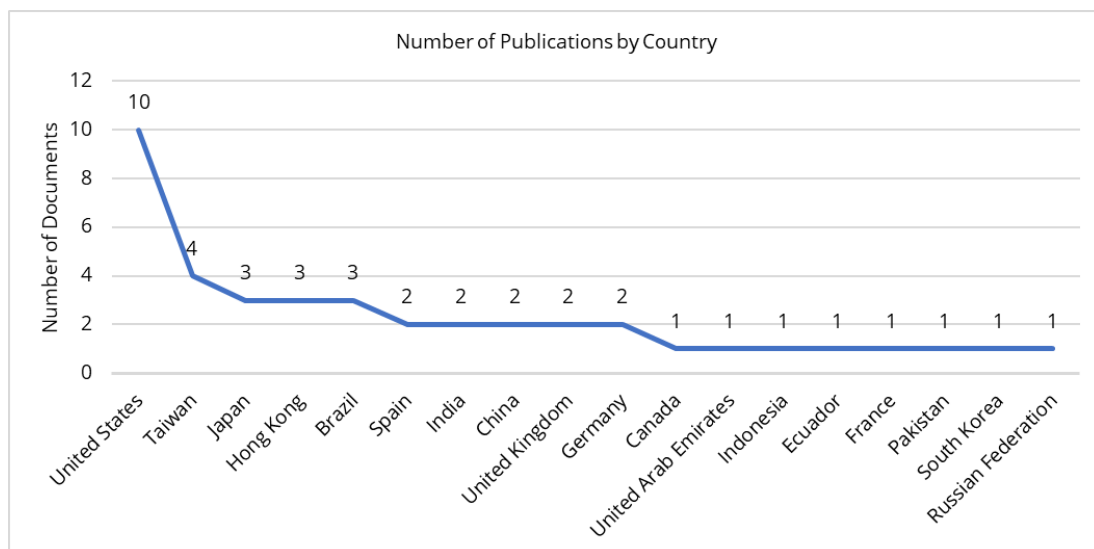


Figure 2. Number of Publication by Country

Figure 2 presents the distribution of research publications according to their country of origin, revealing some geographical trends in artificial intelligence and project-based learning. With a total of 10 publications, the United States is the top contributor to this research field by a large margin. Taiwan contributes four publications; meanwhile, Japan, Hong Kong, and Brazil contribute three publications, indicating a solid predominance in Asia and South America. As for the characteristics of the research field, this data indicates that it is shaped by institutions in regions not only low in economic development but also in high technology and high research intensity, but also by a diverse and concentrated set of countries leading the pack.

4. Data Analysis

A total 41 articles deemed relevant through the screening were systematically exported in RIS format, ensuring compatibility with advanced bibliometric analysis software. These 10,128 articles were then processed through VOSviewer software (version 1.6.20). This software offers a powerful tool for the visualization and interpretation of complex bibliometric data. This analysis was smoothly contrived with three significant visual modalities Network Visualization focused on the connectivity as well as disparate points among articles, Overlay Visualization displayed the temporal and thematic trends, and Density Visualization to Illustrated the intensity as well as concentration of research activities in specific areas.

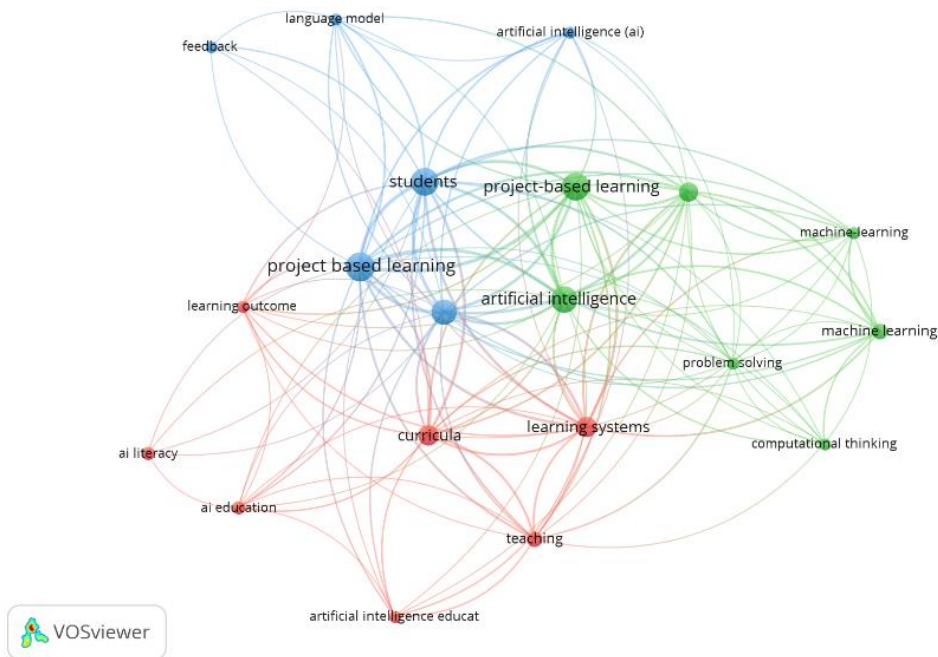


Figure 3. Overlay Visualization by Keywords on VOS Viewer Dataset

The keyword co-occurrence data is illustrated using a network visualization in Figure 3, which gives an overview of the relations between the different terms. Also, the overlay visualization shows three separate clusters based on keywords of interest with some connectivity between AI, project-based learning, and curricula. Yet such links seem tenuous, especially where artificial intelligence is concerned in the context of project-based learning strategies. The finding of little overlap is notable since it indicates a missed potential in the literature, and that the intersection of these areas is yet to be comprehensively explored.

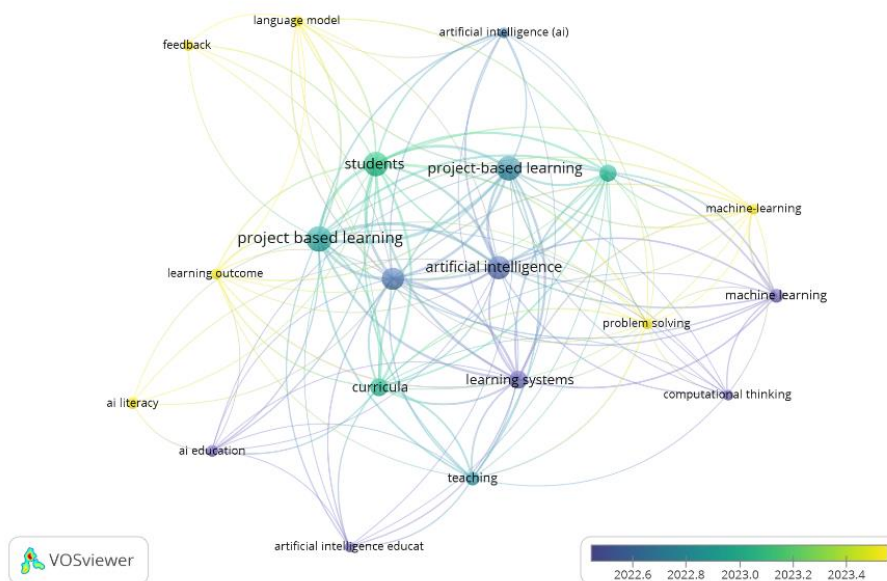


Figure 4. Overlay Visualization by Keywords on VOS Viewer Dataset

Figure 4 presents data on keyword co-occurrence through an overlay visualization. This overlay visualization indicates that research on the topics of Artificial Intelligence (AI) and Project-Based Learning (PjBL) is relatively new, with initial studies emerging in 2022, represented by purple-colored nodes. Meanwhile, keywords depicted in yellow represent the most recent research conducted in 2024. Within this cluster, keywords such as 'AI literacy,' 'learning outcome,' 'feedback,' 'language model,' 'machine learning,' and 'problem-solving' are categorized as part of the most recent studies in the field."

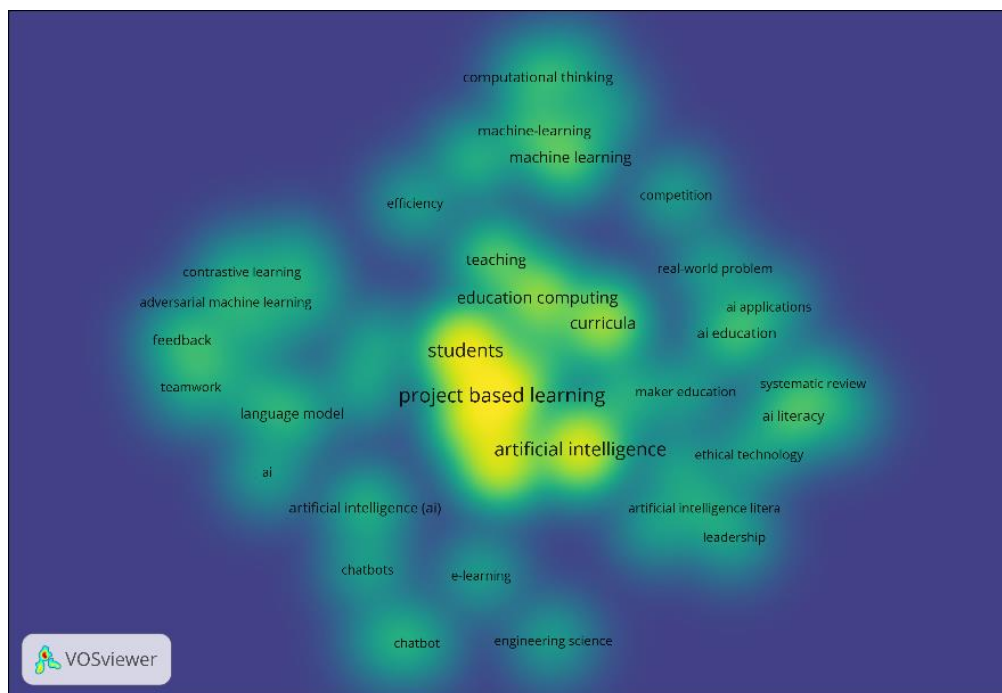


Figure 5. Density Visualization on VOS Viewer Dataset

Figure 5 illustrates keyword co-occurrence data via a density visualization, providing insights into the concentration and intensity of research efforts linked to particular keywords. This visualization shows that the keywords project-based learning, artificial intelligence, and students exhibit a notably high density, suggesting a significant emphasis on these topics of research. That said, the links among these three keywords seem rather tenuous, suggesting that their interplay has not been well explored. This observation highlights a gap in the current research landscape and advocates for future studies to explore these relationships in greater depth to improve understanding and facilitate the development of more thriving and holistic research in this field.

Discussion

1. Bibliometric Review by 41 Document on VOS Viewer Dataset

1.1. Interdisciplinary Collaborations in the Co-authorship Network

The visualization of the co-authorship network further highlights the important cross-disciplinary collaboration links which are critical for developing knowledge of project-based learning (PjBL) and education artificial intelligence (E-AI). It looks like

collaboration between groups of authors from multiple fields, like education, computer science, psychology, and engineering (Grover et al., 2024; Huang, 2024; Schleiss et al., 2022). This cross-disciplinary exploration reveals the complexity and richness of AI-influenced initiatives within education and their possibility of changing learning spaces.

Among other groups within the network, there is a group of computer scientists and educational technology authors. These are researchers who work on designing infrastructure and tools that help implement Project-Based Learning (PjBL) that professors can use by combining technology with pedagogy. One such group in the network is the authors in educational technology and computer science. These scientists focus on the development of PjBL tools and infrastructures, bridging technology momentum and pedagogy. For instance, creating personalized learning experiences using machine learning algorithms will require joint efforts from both AI developers and educators to ensure these tools serve educational objectives and ethical standards.

Another major grouping brings together researchers from psychology and education. This group has more frequently addressed the cognitive and social aspects of PjBL combined with AI, in which the interaction between AI tools and collaboration, student involvement, and problem solving are studied (Chen & Qin, 2023). Collaboration between psychologists and educators—not just computer scientists—is key to building AI systems that enhance not just learning outcomes, but also social and emotional development for students.

There are also clusters of interdisciplinary collaborations emerging that focus on the ethical implications and governance of AI in education. Philosophers, computer scientists, and educational leaders have joined forces to explore the ethical use of AI tools to facilitate PjBL on aspects such as equity, transparency, and privacy. Such a synergy very much indicates the need for guidelines which ensure the ethical use of AI technologies in different educational contexts.

A related but smaller cluster includes works by researchers in the engineering and education disciplines on real-world effective practices of AI in PjBL. This cluster explores the integration of AI in engineering education for simulating scenarios that mirror real-life problem-solving. Scalable methods are used, which emphasize the importance of employing AI in the real world and practical applications, thus preparing students for future jobs in AI-oriented industries.

The network shows strong interdisciplinary efforts, while highlighting areas where further collaboration might make research even more impactful. As one example, the low cross-cluster connection between AI ethics and technical development suggests an opportunity for greater integration of ethical considerations throughout the AI system design process. Likewise, educational psychologists could forge stronger connections with

computer scientists to ensure that AI tools are technically savvy as well as developmentally sound.

1.2. Interdisciplinary Gaps in the Co-authorship Network

Collaboration among groups of authors from diverse disciplines (education, computer science, psychology, engineering, etc.) is evident from the cited sources. The multidimensional investigation demonstrates how many layers deep AI-sponsored projects can be in the domain of education and the implications they spurt into the learning ecosystems. Within this web are many communities, such as educational technology and computer science. These developers work on designing PjBL technology infrastructure, bringing technical development and pedagogical design together.

The disconnect between AI engineers and educational psychology is another significant one. PjBL AI tools necessitate a deep comprehension of social and cognitive dynamics and processes, including student involvement, motivation, and teamwork (Grivel et al., 2023; Marckwardt et al., 2022; Ng, Xinyu, et al., 2024; Sajadi et al., 2023). Except for some communication between each of them, little is done in each of these domains separately, except from some communication between them, which could lead to AI systems that fall short of meeting fundamental development requirements. Reducing this gap could improve AI tools' psychological suitability and guarantee that they support social-emotional development and education.

Similar underexplored potential to create an interdisciplinary curriculum exists in the lack of links between engineering and education research (King, 2018; Lokare & Jadhav, 2024). Well-designed Project-Based Learning (PjBL) commonly allows students to solve practical issues, but the two fields operate as silos, presenting barriers to the worldwide integration of AI in STEM (Heilala et al., 2023). Closer collaboration between education experts and engineers could result in creative teaching models that employ AI to improve individual learning activities.

Another related issue is the disconnect between AI literacy efforts and technical research. Though these clusters are only loosely connected, AI literacy is critical to equipping students with the ability to understand and use AI technologies responsibly. This gap limits AI literacy programs from including the latest advancements in AI, potentially leading to poorly prepared learners. Strengthening this partnership would ensure that future AI literacy efforts are informed by cutting-edge technical research and thus are relevant and effective.

In addition, research on educational leadership and policy remains weakly networked with the broader technical and pedagogical communities. To realize successful integration of AI at scale in PjBL, leadership is required to manage resources, overcome systemic barriers, and leverage evidence-informed practices. This collaboration among different areas of expertise could lead to adaptable strategies that foster the integration

of AI into diverse educational contexts, ensuring balanced advancements and long-term viability in the sector.

Interdisciplinary collaboration is further restricted by geographical and institutional barriers. Researchers typically collaborate mainly in groups that are specific to their discipline or organization, limiting the perspectives that can contribute to and the generalizability of findings. Trying to promote more international collaborations and inter-institutional projects enacts thus less divisions and enables the exchange of creativity over multiple cultural and educational initiatives.

Addressing these interdisciplinary gaps is key to advancing the research of PjBL and AI. If the research community works on optimizing partnerships that promote ethical, psychological, pedagogical, engineering, literacy, and leadership approaches in order to support the development of AI-based educational solutions in an efficient, fair, ethical, and scalable way (Xing et al., 2023). Bridging these gaps will lead to a greater impact of PjBL and AI across learners and educational contexts.

1.3. Mapping Global Research Collaboration in Project-Based Learning and AI

The global collaborative research network of project-based learning (PjBL) and artificial intelligence (AI) has different interaction characteristics of researchers in different regions. The visualization highlights clusters of research collaborations, largely formed by geographical or institutional proximity. These clusters reflect the localized nature of research, suggesting that researchers tend to publish more with colleagues and at their specific geographical or academic institutions (Khan et al., 2024).

Although these regional collaborations allow for a more concentrated focus on specific research areas, they also point to a relative lack of engagement between regions. Weak edges between the clusters suggest a lack of robust global collaboration in specific fields. It could be the result of geographic dispersion, cultural differences, or institutional barriers. This kind of homogenisation can lead to redundancies in the research landscape and a limited range of views being considered to inform research agendas, emphasising the need for systems that help facilitate greater international engagement.

Interspersed throughout this body of analysis are hubs in the network, points of confluence that connect otherwise disparate clusters. Each of these nodes represents individual researchers or institutions that are heavily collaborative in nature and span many disciplines. Such collaboration is essential, as it enables the harmonization of research efforts worldwide while also supporting and streamlining the transfer of best practices or methodologies across different settings.

These connectivity networks often spur innovation by blending ideas from different scientific ecosystems. The network also shows pathways for improving global collaboration. Underconnected areas or isolated clusters, for example, might benefit from

better links to more substantial ones. More linkages in this direction would enrich the research landscape, providing unique local perspectives and addressing challenges that might otherwise not be prioritized. This can be enhanced through joint research programmes, joint conferences, cross-institutional fund tapping, and more.

The results indicate that, although there appears to be a lot of collaboration taking place regionally, we have failed to recognize the lack of research integration on a global scale. Collaborating across regional boundaries and overcoming social and institutional hurdles can lead to deeper and more impactful research findings. PjBL and Artificial Intelligence both have the potential to significantly grow in addressing educational issues worldwide, as they utilize interaction hubs and favor inclusivity.

The global collaboration of researchers completely indicates the importance of intensifying the international cooperation level in PjBL and AI. Connecting disparate geographies, especially nuclei of remote and struggling areas by bridging the gap, will not only expand the research dividends but also help instigate innovations that meet the needs of global education (Ito et al., 2020). These findings reinforce the need to make a concerted effort to connect researchers around the world as well as ensuring that even in a digital world we are fully able to capitalize on the benefits of working across disciplines and borders.

2. Bibliometric Review by Top 10 Document on VOS Viewer Dataset

The study by Ng et al. (2023), which received the most citations (87), was among the few other sources that provided research output on the use of AI (general intelligence) in education from 2000 to 2020. The original detailed review serves as a launching pad for understanding AI's journey from theory to deployment in educational settings (Ng et al., 2023). This means intellectuals appreciate studies that compress much information to orient a discipline and new graduates in a discipline.

Similarly, the study from Kong et al. (2023) emphasizes AI literacy, an important subject in the era of prolific AI technologies in learning spaces. Due to the specific nature of frameworks for literacy, moving towards them within learning contexts demonstrates an intentional shift that seeks to equip teachers, learners, and decision-making bodies with the knowledge and skills to navigate the complexities of AI-mediated learning environments (Kong et al., 2023; Kuo et al., 2020). These research emphasize the trend of focusing on readiness and the ethical use of AI in higher education, capturing the sense of urgency with which academic institutions are grappling with the opportunities and challenges that AI has created.

The temporal study indicates that most high-impact articles occur between 2018 and 2023, aligning with significant advancements in AI technology, particularly in machine learning, natural language processing, and adaptive learning systems (Chang & Lin, 2024; Lee & Kwon, 2024). Based on region, contributions from the US, Europe, and some parts

of Asia are clearly leading. The finding on these regions elaborating on the phenomenon that the advanced technological regions dominated and strengthened that very position on global educational research. It has long been evident that these topics have received increasing levels of research and funding attention, which has created better access to funding, infrastructure, and expertise on these topics. While this brings an important question of inclusivity and diversity, low-resourced contexts are still too sparse in the landscape. We must combat this inequity to ensure that AI-powered educational tools are equitable and suited to a wide variety of global contexts (Ghani, 2022; Ito et al., 2021; Ng, Su, et al., 2024).

The exploration of the role of Artificial Intelligence in engineering education with a persistent focus on the combination of technical knowledge and innovative teaching models (Martín Núñez & Lantada, 2020). This integration emphasizes AI's multi-faceted character to addressing complex problems and promoting proactive, experiential learning. This is evidenced as existing literature, which has studied such relationships as presented in Kahn and Winters (2021), offers valuable insights into how traditional educational theories can be further refined to keep pace with those cutting-edge technology developments (Kahn & Winters, 2021). This kind of emergent scholarship reflects an increasingly necessary comprehension of how high-level theoretical considerations will need to pervade to ensure that the application of AI to education can remain meaningful and sustainable.

As many of the most cited works come from these journals, such as those published in *Education and Information Technologies* and the *British Journal of Educational Technology*, the disciplines strongly benefited from these outlets in order to publish their important research. It also creates visibility and sets the research agenda by publishing studies on urgent issues in education. Moreover, scholarly metrics indicate that papers making deep review and proposing theory are usually cited more than papers studying specialization (Zhou et al., 2021). The trend is indicative of an academic community increasingly attracted to research that provides wide, generalizable takeaways and practical recommendations.

3. Critical Analysis of Research Gaps and Future Directions

This study is aimed at analyzing the bibliographic performance of information in respect to artificial intelligence (AI) in project-based learning (PjBL) and suggests a great gap in research in the interdisciplinary approach so far, with discrepancies among one branch of knowledge with another. The thing is very few studies reflect on the great intersection of AI with the social sciences, arts, and humanities. Although previous investigations have largely addressed the technical and pedagogical use of AI by PjBL, the deeper implications of AI with PjBL on the social, cultural, and ethical aspects are yet to be explored. The psychological factors involved also demonstrate that any effective research ecosystem around schools — both in terms of its findings and its methods —

should be embedded in a broader framework ensuring that AI use at schools would be overlaid onto the cultural and social fabric of diverse settings across various countries.

A major additional flaw, which other people have raised, is that there isn't coordination between AI developers and humanities researchers. Research theoretical and applied all too often fails to engage the possibilities of AI for improving creative problem-solving, critical thinking, and ethical reasoning—the very skills that are so vital to so many fields in the humanities. For example, the use of AI to propose integrating artificial intelligence in new ideas for arts-based PjBL to teach cultural representation and historical analysis. Bridging this gap would both add richness to the scope of uses of AI as well as help people understand how AI can be useful in supporting a broader set of pedagogical goals, namely interdisciplinary teaching and social-emotional learning.

Furthermore, some basic ethical and philosophical issues concerning the AI incorporation to PjBL must be tackled. There have been more studies on AI ethics, but these almost uniformly seem focused as a separate stream from the technical and educational studies that end up inadvertently creating functional but misaligned AI systems with respect to the social constructs and value. Future research should aim to develop ethical frameworks for AI that are co-designed by collaborative interdisciplinary teams of ethicists, educators, and technologists.

These frameworks could guide the design of AI tools that balance creativity with equity, inclusivity, and cultural sensitivity. Future studies have to adopt a more inclusive and integrative approach, reinforcing collaboration among disciplines. Researchers can, thus, leverage their expertise from social sciences, arts, and humanities to develop culturally and ethically aware AI-based PjBL solutions while integrating efforts from technical innovation. That we will ensure the transformative potential of AI within education would be applied towards solving global problems, facilitating cross-disciplinary learning opportunities and equitable access for all.

Conclusion

The bibliometric analysis of AI conducted in project-based learning (PjBL) indicates substantial interdisciplinary development while also signalling significant voids that limit the comprehensive adoption of AI into education. A major flaw lies in the lack of connection between AI on the one hand, and social sciences, arts, and humanities on the other hand, as the most active part of the existing scientific literature is focused on more technical and educational issues regarding the advancements of AI, often detached from the general social, cultural, and ethical aspects of implementing AI. Such blunders illustrate the urgent need for robust frameworks that capture diverse perspectives to ensure AI applications in education are contextually meaningful and socially relevant.

In addition, limited engagement of AI developers with the humanities makes it difficult for AI to amplify creative problem-solving, critical thinking, and ethical reasoning all of which are core aspects of the humanities. While, for example, integrating AI in arts-focused PjBL could provide innovative approaches to teaching cultural representation and historical assessment, this domain is acutely under-explored. Ethical and philosophical concerns are often dismissed as secondary in importance, and what results is a technically adept AI that does not align with society or values and inclusivity. To meet these challenges, a holistic and inclusive approach is necessary in future research with more effort of collaboration among educators, technologists, ethicists, and would-be humanists. Such an approach would support the evolution of ethical AI systems that balance technological advancement against fairness, inclusivity, and cultural awareness. Through bridging these gaps and promoting significant interdisciplinary collaboration, these research communities will be able to further harness AI's transformative potential to create PjBL solutions that enhance educational outcomes while also supporting equitable and culturally cognizant pedagogical approaches, empowering students across diverse global contexts.

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