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Research trends on learning environment in science education

Gasanguseyn I. Ibragimov [1*], Maryus Murkshtis [2], Natalia A. Zaitseva [3], Yuliya P. Kosheleva [4], Albina R. Sadykova [5], Natalya N. Shindryaeva [6]

[1] Department of Pedagogy of Higher Education, Kazan (Volga Region) Federal University, Kazan, RUSSIA
[2] Department of Criminal Law, Criminal Procedure and Criminalistics, Peoples' Friendship University of Russia, Moscow, RUSSIA
[3] Department of Hospitality, Tourism and Sports Industry, Plekhanov Russian University of Economics, Moscow, RUSSIA
[4] Department of Psychology and Pedagogical Anthropology, Moscow State Linguistic University, Moscow, RUSSIA
[5] Department of Informatics, Management and Technology, Moscow City University, Moscow, RUSSIA
[6] Department of Nervous Disease, Sechenov First Moscow State Medical University, Moscow, RUSSIA

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Abstract

The bibliometric approach examines the science education learning environment by analyzing annual counts, keywords, most cited authors, institutions, funding agencies, and leading journals. 133 articles were indexed in Scopus Database through the use of learning environment and science education keywords from 1989 to 2022. By analyzing the quality and quantity of changes. The focus of the study was to discover patterns in the learning environment of science education publications in Scopus Database. The most commonly used keywords are science education, learning environment(s) and computer science education from the bibliometric analysis. Released in 2021, the study showed that the learning environment in science education was introduced in 1989. A trend of fluctuating distribution regarding articles has been observed. Proposals for future research on the learning environment in science education are made by this study, which takes a global approach.

Keywords: bibliometric review, learning environment, science education

INTRODUCTION

The learning environment can be defined as the physical and social context in which teaching and learning takes place. It contains the physical environment, teacher-student interactions, and culture of classroom (Niyazova & Khuziakhmetov, 2021; Smolyaninova et al., 2021; Wang et al., 1993).

The learning environment is an important factor affecting students' attitudes, motivation and achievement in science education (Knight & Waxman, 1991). Learning environment can be categorized as academic environment, physical, and psychological environments. Brooks (2010), Dhanapala and Premaratne (2021), and Softa (2011) stated that learning environment would help to improve academic success. Additionally, well-designed learning environment helps to students to have effective learning according to Ashton (2001), Kilei (2012), Umar (2017), and Vosniadou et al. (2001).

It is widely acknowledged that the learning environment plays an important role in student achievement and engagement in science education. Some of studies within the past decade have highlighted the importance of creating positive and stimulating learning environments for students. For example, Smith (2011) found that students in classrooms with interactive science centers had significantly higher science achievement scores than those in traditional classrooms. Similarly, a study by Jones et al. (2014) revealed that students in outdoor education programs had a greater understanding of ecological concepts and a stronger connection to nature. Inquiry-based learning holds great promise in boosting student engagement and critical thinking capacities in science education, according to Archer-Kuhn et al. (2020) and Kolb and Kolb (2005). These studies underscore the need for science educators

✉ guseinibragimov@yandex.ru **(*Correspondence)** ✉ murkshtis-my@rudn.ru ✉ zaitseva-itig@mail.ru
✉ yu.p.kosheleva@mail.ru ✉ albsad2008@yandex.ru ✉ mont76@mail.ru

Contribution to the literature

- This article significantly advances the discourse on science education by conducting a comprehensive bibliometric analysis that delves into the multifaceted dimensions of learning environments, unraveling trends, influential research, and emerging themes that collectively shape the pedagogical landscape.
- This study offers a foundational resource for educators, researchers, and policymakers to comprehend the intricate interplay between instructional settings, technology integration, and cognitive development by meticulously mapping the evolution of research pertaining to learning environments in science education.
- Through an incisive bibliometric exploration, this article underscores the evolving paradigms of learning environments within the realm of science education, guiding future scholarship and pedagogical practices while fostering a deeper understanding of the dynamic factors influencing effective teaching and learning experiences.

to create dynamic and engaging learning environments that foster student curiosity, exploration, and understanding. For instance, Patel et al. (2018) found that many scientific instructors lack the support and training required to successfully incorporate technology into their classes. Pramathevan et al. (2020) emphasized the usefulness of technology-based science classrooms for bright children in a similar way. More research is required to determine the effects of online learning environments on student engagement and performance in scientific classrooms, according to a study by Kim et al. (2020). Additionally, research by Chen et al. (2021) revealed that underfunded and subpar learning settings in science classrooms had a disproportionately negative impact on pupils from underprivileged backgrounds.

Over time, studies on the learning environment in science education have changed. The utilization of 3D virtual environments and the effects of technology advancement in science education were initially the main points of attention (Kampinga et al., 2021; Shudayfat et al., 2023). Later, the idea of blended learning environments—which places a focus on collaborating and increasing student understanding—emerged as a means of integrating technology into education (Kervinen et al., 2020). Using embodied investigations, comedy, and narrative representation, there has been a recent trend toward examining how students integrate science learning into their everyday lives Kalyon (2020). According to Aslam et al., (2020) the development of assessment tools to evaluate elements of learning environments and their influence on student success and attitudes has also received attention. The students' enthusiasm to learn science and the value of science lab conditions have both been acknowledged (Cavanagh & Fisher, 2018). In addition, Thomas & Chantharanuwong (2022) constructed the dimensions and component structure of the Thai context of the Metacognitive Orientation Learning Environment Scale - Science (MOLES-S). Furthermore, Türkmen (2022) determined that learning may occur when informal learning contexts provide people a feeling of good emotional fulfillment.

Collaboration and cooperation between educators, researchers, and other stakeholders are essential for developing effective learning environments in science education. According to research by Andersen et al. (2018), educators who participated in professional learning communities had greater levels of self-efficacy and were more likely to use inquiry-based learning in their classrooms. Like this, Green et al. (2019) found that university-school relationships can offer teachers beneficial chances to participate in professional development and enhance their science education.

Science teachers should prioritize establishing a favorable learning environment, as it greatly impacts students' attitudes toward science, participation levels, and ultimately, their academic achievements. Bibliometric methods are applied to illuminate knowledge deficiencies in the existing research field. A thorough examination of trends, patters, and information deficits within the discipline will be conducted to identify pivotal factors, burgeoning subjects, and seminal works. Enlightening research requires interpretations of such magnitude to guide methodologies, sculpt academic structures, and hone evidence-based pedagogical strategies to promote student interest and ardor for scientific disciplines. Through an exhaustive investigation, the piece aims to deepen knowledge of the vital function performed by educational settings in shaping the future scientific leaders.

This study serves to fulfill a crucial knowledge gap in the field of science education. Despite recognizing the paramount significance of the learning environment in shaping students' learning outcomes and attitudes towards science, there exists an inadequacy of comprehensive studies that systematically scrutinize the available research landscape on this subject matter. The motivation behind this investigation is rooted in the need to critically evaluate and integrate the extensive corpus of literature on learning environments in science education. The research inquiries guiding this study involve the identification of pivotal trends, influential authors, popular topics, and the most frequently cited publications in the field. Furthermore, the study

endeavors to explore emerging areas of interest and address any discrepancies or underrepresented themes within the existing literature.

The main objective of this bibliometric analysis is to furnish educators, policymakers, and researchers with invaluable perspectives to optimize the configuration of science classrooms, stimulate practical teaching methodologies, and establish a supportive learning milieu that cultivates students' curiosity, involvement, and accomplishments in science education. By bridging this informational void, the article aims to substantially contribute to the progression of science education and expedite evidence-based decision-making in the quest for more influential and comprehensive educational encounters for students.

Addressing the current gap in knowledge within the field of science education, this study uses a comprehensive bibliometric analysis of the existing literature on learning environments. The study aims to discern trends, identify knowledge gaps, influential authors, and key research contributions that can enhance the quality of learning experiences and pedagogical practices in science education.

Research Questions

This bibliometric analysis focused on papers connected to the learning environment in science education from 1989 to 2022, yielding the four research questions (RQs) listed below:

- **RQ1.** What were the yearly fluctuations in the articles related to learning environments in science education?
- **RQ2.** What were the learning environment research's most frequently used keywords?
- **RQ3.** Helping researchers and educators stay up to date on important developments, who are the most frequently cited authors in articles regarding the learning environment in science education?
- **RQ4.** Which scholarly publications, nations, educational organizations, and financial sponsors are the primary contributors conducting research on educational settings in the field of science education?

METHOD

Scopus Database was used to perform a thorough literature search. Articles, conference papers, and reviews from 1989 to 2022 were included in the search. "Learning environment" as article title and "science education" as keyword were the search phrases used. Bibliometric study was carried out with the aid of Scopus Analysis and VOSviewer programs. This study included academic articles written in peer-reviewed journals in English language. Conference proceedings, reviews, and book chapters (total 109 documents) were not included in the bibliometric analysis in this study. A total of 133 articles were included in the analysis. Thus, it is aimed to reflect the qualitative and quantitative changes for the articles related to this subject in the journals indexed in Scopus Database in the last 33 years by choosing a long period. The distribution of documents is shown in **Figure 1**.

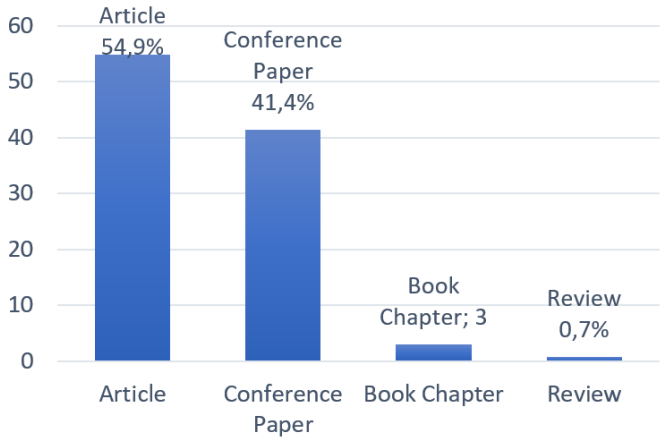

Figure 1. Distribution of documents related to learning environment in science education (Source: Authors' own elaboration) (Source: Authors' own elaboration)

As can be seen from **Figure 1**, most of the documents were articles (54.9%) and conference papers (41.4%). The rest of the documents were book chapter (3.0%) and reviews (0.7%). Document were published in 75 different journals or books, with the leading journals being Learning Environment Research, International Journal of Science and Mathematics Education and EURASIA Journal of Mathematics, Science and Technology Education.

Bibliometric Analysis

Bibliometric review is a research method that uses bibliometric data (i.e., publication, author, and citation data) to analyze and understand a particular area of research (Ahmi, 2021).

A field's key publications, authors, and trends may be found through bibliometric reviews, which can also be used to evaluate the significance and influence of a certain subject or researcher (Ball, 2017). The educational sciences, social sciences and humanities have all made extensive use of these periodicals. It should be highlighted that biases and restrictions might still affect bibliometric reviews. When interpreting the results, it is crucial to consider the constraints imposed by the data sources employed, such as the database scope and publishing language (Supriadi et al., 2021).

One of the most widely used methods for bibliometric reviews is citation analysis. Citation analysis counts how often a publication is cited by other publications and uses this information to infer the importance or impact of the publication. Studies have

shown that citation counts are a reliable indicator of a publication's impact and correlate strongly with other impact measures such as the h-index and the journal impact factor (Abbasi & Thelwall, 2010; Bornmann & Leydesdorff, 2015).

The other popular method for bibliometric reviews is co-citation analysis involving identifying groups of publications that are frequently cited together. These groups of publications are assumed to be related in some way and can be used to identify the main research topics and trends in a field (Kocak & Soylu, 2022).

Another development in recent bibliometric research is the use of network analysis to investigate connections between publications and authors. Network analysis is a potent technique for comprehending the organization of scientific communities and the exchange of ideas between academics, claim Newman et al. (2001). Network analysis has recently been utilized in research to explore connections between articles in a field (Tang et al., 2016).

Using a bibliometric approach, this study examines eligible research on the learning environment in science education by analyzing metrics including annual document counts, keywords, authors, institutions, and top journals.

The bibliometric analysis method is particularly suitable for this study. Several persuasive arguments justify conducting a literature metrics analysis. Initially, a quantitative evaluation of scientific publications using bibliometrics enables a comprehensive and structured examination of a sizable corpus of research related to a particular area of study. In the sphere of science education, there is an abundance of scholarly literature, thus complicating a thorough examination of the current knowledge landscape. Bibliometric evaluation enables an in-depth investigation into a vast array of academic works, thus facilitating the recognition of significant developments, prominent scholars, and rising areas of study. Secondly, bibliometric analysis offers a stringent approach to assessing the impact of research and scholarly contributions. Through the scrutiny of citation patterns, co-citations, and publication trends, the study can unveil the most frequently cited authors and prominent publications in the field of science education's learning environments. This information furnishes invaluable insights into the academic influence and acknowledgement of scholars' endeavors, thereby contributing to a comprehensive comprehension of the field's intellectual framework and influential research clusters. Moreover, the utilization of bibliometric analysis enables the discernment of lacunae in knowledge and directions for future research within the study domain. Through the examination of keyword and theme co-occurrence, the investigation has the capability to expose areas that are still inadequately explored or nascent, thus highlighting potential pathways for forthcoming research. The comprehension of these knowledge gaps is indispensable for steering researchers, educators, and policymakers in addressing specific challenges and formulating evidence-based strategies to augment science education learning environments. Lastly, the approach's objectivity and reproducibility enhance the study's reliability. The systematic, evidence-based nature of bibliometric analysis contributes to the elevation of credibility in the conclusions deduced. This objectivity is essential in providing a solid foundation for evidence-based decision-making and fostering confidence in the results among the academic community and stakeholders in science education.

In conclusion, the bibliometric analysis method is highly suitable for this study as it allows for an extensive and objective assessment of the research landscape, offers insights into research impact, identifies knowledge gaps, and enhances the overall reliability and credibility of the study's findings.

RESULTS

A comprehensive analysis of the data requires going beyond mere description. The authors will utilize a detailed and logical strategy to analyze the data. Initially, the authors will employ diverse statistical and visualization tools to investigate the tendencies and patterns existing within the dataset. Visual representations will be employed to showcase the dissemination of publications through time, leading authors, and interconnected networks. The authors not only visualize these patterns but also provide a thoughtful interpretation of their significance in science education. Moreover, to tackle the matter of descriptive exposition, the authors shall incorporate a qualitative content analysis methodology to supplement the quantitative bibliometric analysis. This shall entail scrutinizing the substance of extensively referenced papers and co-cited clusters to extract understandings into the theoretical frameworks, methodologies, and pivotal discoveries propelling the investigation on learning environments in science education. By means of this content analysis, the authors shall be able to furnish more intricate and significant interpretations of the findings.

Bibliometric Analysis Findings

Figure 2 displays the annual accounts of the documents. **Figure 2** also shows that the number of articles and citations did not significantly increase until 2001. An increase of a significant proportion took place in 2003 for the articles related to the learning environment in science education. The most articles were published in 2021.

Figure 3 reveals the number of citations for the learning environment in documents about science

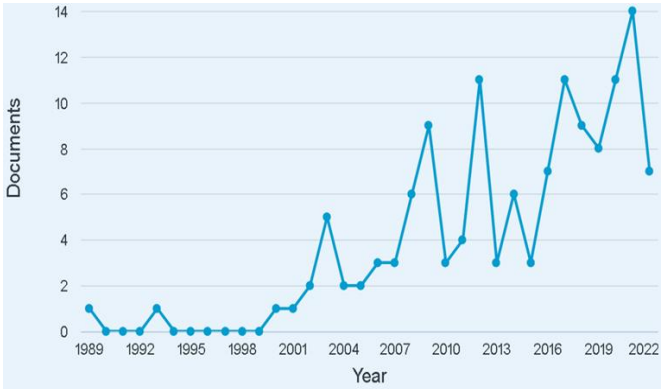

Figure 2. Science education documentation annually accounts for the learning environment (Source: Authors' own elaboration)

education from 2007 to 2022. In general, the number of citations to studies on the subject increased between 2007 and 2022, reaching the highest number in 2022.

The Most Used Keywords in Articles

Author keywords were chosen as a unit of analysis and "co-occurrence" as a kind of analysis. Three repetitions were chosen as the minimum quantity for the keywords. 27 keywords have automatically emerged as the total. The phrase "science education" was frequently employed (f=84), learning environment(s) (f=44), computer science education (f=32), game-based learning (f=9), motivation (f=6), constructivism (f=5), attitudes (f=5), etc. **Figure 4** reveals the distribution of the most frequently used keywords in articles by year.

The Most Productive Authors

The most productive researchers on this topic are Fraser, B. J. (seven publications), Boyer, K. E. (four publications), Ito, K. (four publications), Lester J. (four publication), Lester, J. C. (four publications), Mott, B. (four publications), etc. **Figure 5** shows the most

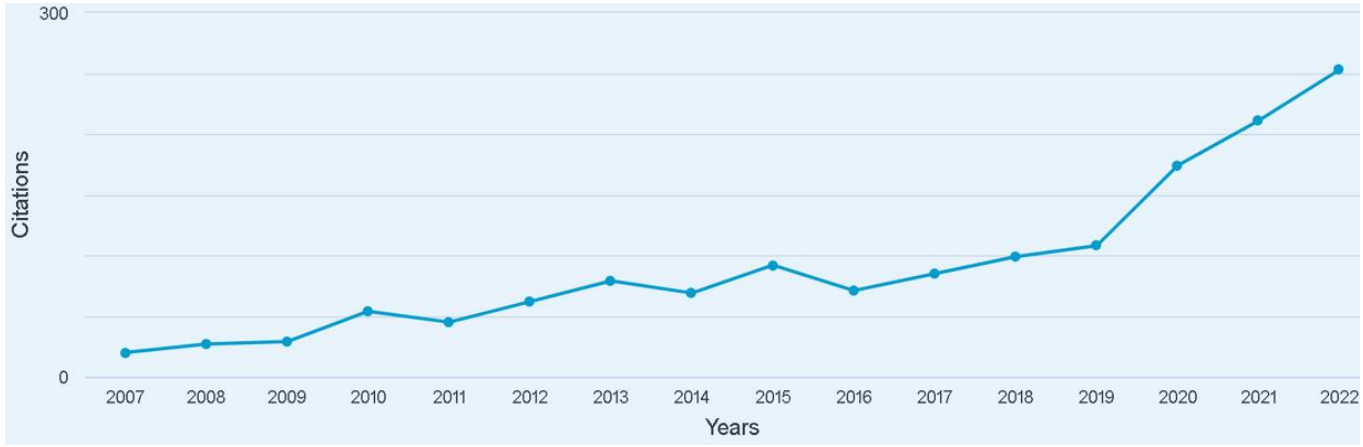

Figure 3. The number of citations in science education papers related to the learning environment (2007-2022) (Source: Authors' own elaboration)

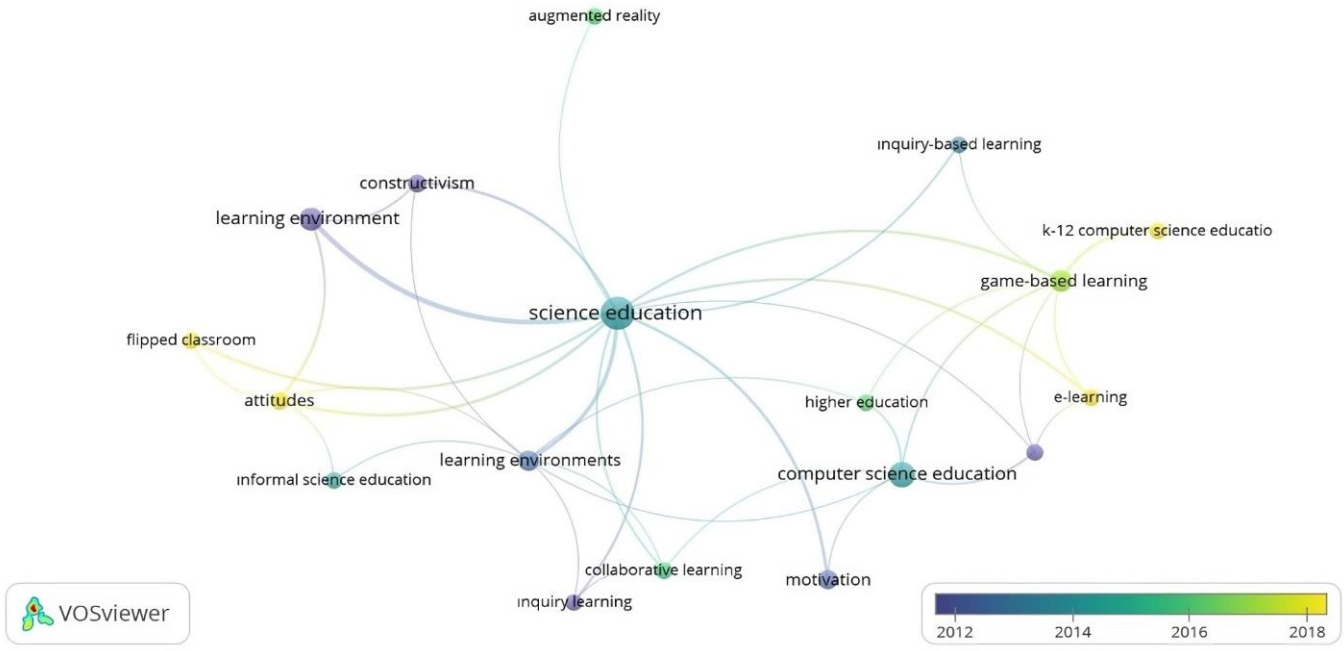

Figure 4. The distribution of the most frequently used keywords in articles by year (2011-2019) (Source: Authors' own elaboration)

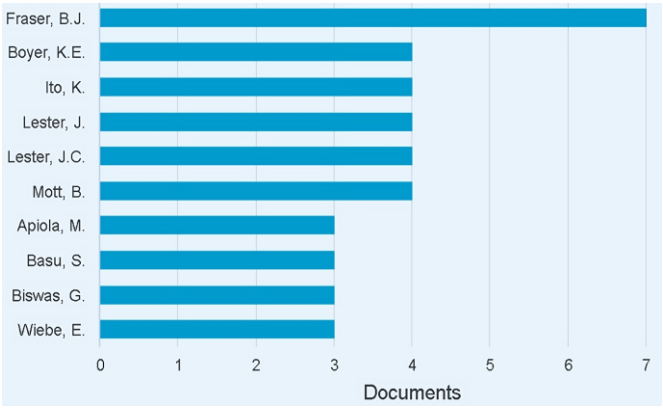

Figure 5. Most productive top-10 authors related to learning environment in science education research (Source: Authors' own elaboration)

productive authors related to learning environment in science education research.

On the other hand, "citation" was chosen as the analysis type and "author" as the analysis unit. Two articles and 50 citations were chosen as the minimum number of publications and authors, respectively, for each author. Twelve writers have automatically been determined to be the correct number. The most productive authors in terms of number of citations were Vosniadou et al. (2001) (310 citations, 54 articles); Tsai (134 citations, 19 articles); F. Spooner (181 citations, six articles).

Additionally, with respect to the most productive authors, the investigation will endeavor to underscore the importance of their contributions beyond the sheer volume of publications, accentuating the impact and influence of their work on the domain of science education. To proffer a more profound analysis of publication allocation across nations, the authors will integrate a comparative evaluation that considers the research output relative to the size of the academic community in each country. By incorporating these enhancements, the analysis segment will evince augmented rigor, furnishing a more comprehensive and valuable apprehension of the research findings in the context of science education learning environments.

Top Journals

A total of 75 journals, 40 conference proceeding, 14 book series and four books have published research on learning environment in science education from Scopus Databases. In addition, 13 documents published in "Learning Environment Research", seven documents published in "International Journal of Science and Mathematics Education", eight documents published in "Lecture Notes in Computer Science" and five documents in published in "Frontiers in Education Proceeding".

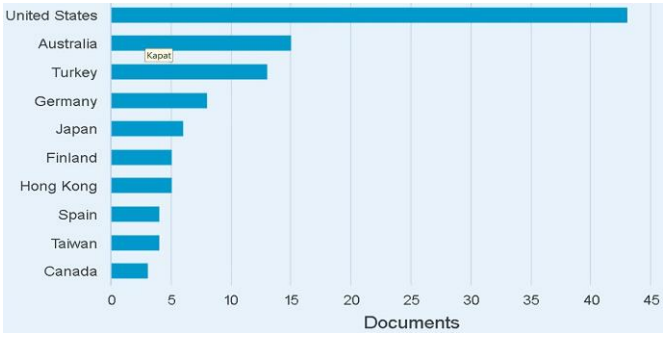

Figure 6. Countries publishing the most articles related to learning environment in science education (Source: Authors' own elaboration)

Countries Publishing the Most Articles

Countries were chosen as the unit of analysis and "bibliographic coupling" as the analysis type. Three were chosen as the minimum number of articles for each nation. Sixteen nations have automatically been determined to exist. Countries publishing the most articles were USA (43 articles), Australia (15 articles), Turkey (13 articles), Germany (eight articles), Japan (six articles), Finland (five articles), Hon Kong (five articles), Spain (four articles), Taiwan (four articles), and Canada (three articles).

This result is at an expected level and in line with the literature considering the number of researchers and academic journals on this topic in the US. **Figure 6** shows the countries that publish the most articles.

Institutions

154 institutions have contributed to 208 publications about learning environment in science education in Scopus. Scopus Database shows that the most contributive institutions were NC State University (nine documents), Curtin University (nine documents), Vanderbilt University (four documents), Aoyama Gakuin University (four documents), University of Georgia (four documents), Helsingin Yliopisto (three documents), etc. (**Figure 7**).

Funding Agencies

In Scopus, 38 funding agencies expressed an interest in investing in research on the learning environment in science education. Four funding agencies funded the most research projects on this research topic were "undefined", National Science Foundation, National Science Council, and Australian Research Council as can be shown in **Figure 8**.

DISCUSSION

This bibliometric review examines the literature on learning environments in science education produced between 1989 and 2022 in depth. This study aimed to

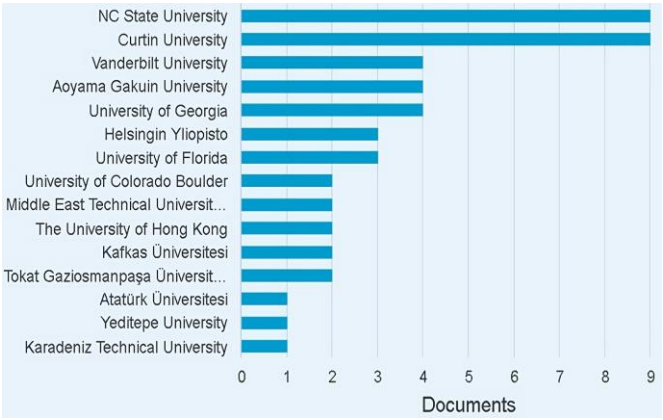

Figure 7. Institutions contributed learning environment in science education studies (Source: Authors' own elaboration)

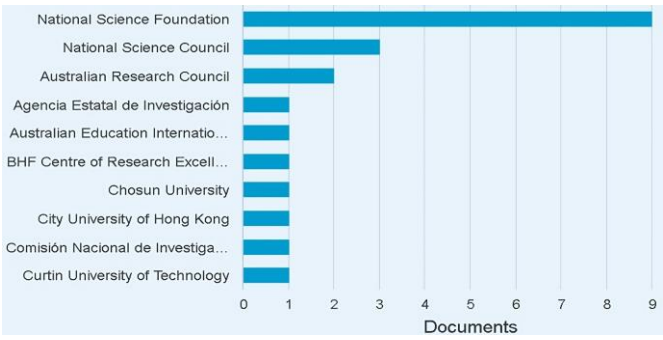

Figure 8. Organizations interested in funding studies on the teaching and learning process in science education (Source: Authors' own elaboration)

offer an overview of the present level of research on the issue as well as highlight major trends and difficulties that need to be addressed. It was seen that bibliometric studies on this subject are not very common in literature. In addition, there are many reasons why such a study is needed.

First, the reason for needing such a study is to open the horizons of researchers interested in this topic by means of bibliometric analysis because bibliometric studies are very important to perceive "big picture" about the subject according to Seref and Karagoz (2019). Secondly, to provide the widest possible coverage and perspective, the bibliometric analysis includes peer-reviewed articles in English.

This study revealed the bibliometric analysis findings of papers relevant to the learning environment in science education published in journals indexed in the Scopus Database. The results revealed that that learning environment in science education research were not regularly changed from 1989 to 2022 according to Scopus Database. The reasons for this could be that the subject was very broad, comprehensive, and perceived as a classic subject. The increase in the number of citations of studies on this topic over time can be explained by the increase in interest in the topic and the increase in the number and diversity of studies (Singer et al., 2020). According to the findings of bibliometric analysis, the most used key words were science education and learning environment. This is consistent with the topic of this study and literature (Cetin-Dindar, 2015).

The most productive authors were generally from developing or developed countries. This finding is consistent with previous research. (Arici et al., 2019) and can be evaluated as expected result. Likewise, the origins of top journals were also from developed countries as usual. Furthermore, countries publishing most articles were again from developing or developed countries (Agbo et al., 2021). The investigation of the learning environment in science education was supported by various institutions and funding agencies, primarily hailing from developed and developing nations encompassing the United States, Canada, Australia, Hong Kong, and Turkey (Ioseliani et al., 2023).

CONCLUSIONS

The bibliometric data reveals a noticeable growth in the volume of science education literature that concentrates on the exploration of learning environments in recent times. This trend showed that this topic had importance in the field and that researchers were actively working on developing and evaluating different types of learning environments in science education.

A bibliometric analysis of the literature on the learning environment in science education produced numerous significant results. A growing organism of research is available in this area with most papers appearing between 2007 and 2022. This suggests that there is rising curiosity on how the learning environment affects students' outcomes in science education.

The data also showed that many publications were in the form of journal articles suggesting that the topic was being widely discussed in academic circles. Also, data revealed that most of the publications are from authors based in developed countries indicating that the topic is being researched mainly in these countries. Besides this, data showed that the most productive institutions were universities and research institutions confirming relevance of learning environment in science education in academic institutions.

In summary, the investigation of the literature on learning environments in science education has exposed a mounting curiosity in the subject in recent times. It is extremely improbable that there has been a substantial rise in the quantity of investigation performed on the topic indicating that it is becoming an increasingly important area of study. This trend also suggested that researchers were actively working to improve and develop different types of learning environment crucial for enhancing student learning and engagement in science education.

The results present valuable insights into significant trends, prominent authors, and co-citation patterns within the field. Nonetheless, certain aspects necessitate critical reflection. The analysis, while comprehensive, seems confined to quantitative metrics, and lacks in-depth qualitative interpretations. A more comprehensive comprehension of research's underlying themes and implications could have been achieved by including qualitative analysis. Furthermore, the research's emphasis on citation and co-citation analysis may not entirely depict the genuine impact and relevance of individual publications. A more balanced approach, integrating other bibliometric indicators and qualitative evaluations, could have fortified the credibility of the research's findings. Additionally, the research's discoveries, while informative, do not explicitly explicate how the identified trends and influential authors may guide evidence-based practices in science education. A more comprehensive discourse on pragmatic consequences of investigation would have augmented the study's magnitude. In sum, the study augments comprehension of research terrain in science education learning environments. But a more amalgamated methodology that encompasses both quantitative and qualitative analysis, and scrutinizes practical implications, would furthermore intensify study's influence and relevance to discipline.

Limitations and Implications for Further Studies

Through a thorough bibliometric analysis, this article clarifies the current state of research surrounding learning environments in science education. The study does have several drawbacks, despite its insightfulness. The selection of databases and sources for data gathering is one significant limitation, which may result in potential bias and an insufficient portrayal of the whole research environment. Moreover, due to the prioritization of citation and co-citation analysis in the study, it is possible that relevant publications with low citation counts yet considerable contributions might be overlooked the study may also fall short in capturing the qualitative parts of the research, such as its real-world impact and the standard of educational procedures in various learning environments, because it is primarily based on quantitative metrics. These limitations present opportunities for further research in the realm of learning environments in science education. To ensure a more thorough analysis, future investigations may surmount database limitations by employing multiple academic databases. To address qualitative aspects, researchers can utilize mixed methods approaches, which combine bibliometric analysis with content analysis, interviews, or surveys, thereby achieving a more profound understanding of the contextual factors influencing learning environment effectiveness. Additionally, investigating the dynamics of learning environments across a range of educational levels, geographical regions, and scientific disciplines may provide valuable insights for tailoring teaching practices to specific contexts and fostering more inclusive and effective science education. The improvement of science education and the enhancement of student learning experiences can be achieved through the exploration of new research directions and the resolution of existing limitations by future studies.

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Ethical statement: Authors stated that the study did not require ethical approval since it is based on existing literature.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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