Language Virtual Laboratory in Higher Education: A Bibliometric Analysis (2012-2022)

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Abstract. This study used bibliometric analysis to examine the trends and assess the impact of Language Virtual Laboratory research in higher education from 2012 to 2022. The research identifies publication trends, the most productive sources, institutions, countries, influential authors, and main themes in this research area. Data were analyzed from 524 documents published across various sources. The results showed a significant growth in publications and citations of Language Virtual Laboratories over the past decade. The article titled " Language Virtual Laboratory in Higher Education : A Bibliometric Analysis (2012-2022) " is the most frequently cited. Universidad Nacional de Educacion a Distancia stands out as the most productive institution. The United States, China, and India are the most productive countries. The most productive author is Esquembre. The main research themes encompass virtual laboratory learning, laboratory systems, implementation techniques, and laboratory elements. These findings provide valuable insights for developing Language Virtual Laboratories to enhance language learning in higher education.

Keywords: Language, Virtual Laboratory, Education

1 Introduction

Language Virtual Laboratories in higher education have increasingly emerged as a significant online learning environment over the past decade (Chen, 2016; Nicolaidou, Pissas, & Boglou, 2023). Technological advancements and innovations in education have facilitated the adoption and development of Language Virtual Laboratories as effective tools for improving language instruction at the tertiary level (Tatnall, 2020). Within this context, a bibliometric analysis of scholarly publications on this subject assumes significance in elucidating the trends and impact within education.

Language Virtual Laboratories are an innovative and interactive learning environment made possible by the development of ICT that aims to help students and other people involved in higher education improve their language

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skills in all aspects of their lives (Chen, 2016; Cai et al., 2017). Since the COVID-19, the use of language virtual laboratories in higher education has become increasingly important since they allow for distance learning and improve the continuity of the teaching process despite geographical barriers.

The importance of Language Virtual Laboratories in higher education has grown rapidly, notably paralleling the increasing use of digital technologies and the internet (Merchant et al., 2014; Al-farsi, 2021). Language Virtual Laboratories have enabled educators and learners to immerse themselves in a linguistically improved and interactive educational experience in recent years (Potkonjak, 2016). Furthermore, the COVID-19 pandemic outbreak in 2020 has provided additional impetus for the adoption and utilization of Language Virtual Laboratories (Khan et al., 2020), as educational institutions have been forced to seek alternative means of delivering instructional content in a virtual realm (Gamage et al., 2020).

Language Virtual Laboratories have increased in popularity among educators and scholars, creating a significant quantity of study and literature studies on the subject. Language Virtual Laboratories have become an exciting subject of study over the last decade (Firmayanto, 2021), attracting the attention of scholars worldwide to investigate their potential and influence in higher education (Ng, 2022). However, there is no analysis of bibliometric in Language Virtual Laboratory research in higher education from 2012 to 2022 has been reported to far.

Recognizing the significance of understanding the development and research trends of Language Virtual Laboratories in higher education, in which study's objective is to conduct a bibliometric analysis of relevant publications within the timeframe indicated. This study will provide an overview of publication and citation trends year by year, the most frequently cited references, the most productive sources, influential institutions and countries in Language Virtual Laboratory research, as well as prominent authors in this field, using a bibliometric approach.

This study aims to answer the following research questions (RQ) in the bibliometric analysis of Language Virtual Laboratories in higher education from 2013 to 2023:

1. RQ1. What are the publication and citation trends regarding Language Virtual Laboratories from year to year?
2. RQ2. Which references are most frequently cited, and which sources, universities, and countries hold the greatest influence in scholarly publications on Language Virtual Laboratories?
3. RQ3. Who are the most productive and influential authors in scholarly publications on Language Virtual Laboratories?
4. RQ4. How do thematic trends evolve in scholarly publications on Language Virtual Laboratories?

The findings of this bibliometric analysis will be useful for academics, educators, and researchers interested in the development of Language Virtual Laboratories in higher education. This study also provides an opportunity to comprehend the latest advancements in this field and identify potential directions for further research. As a result, it is expected that the findings of this study will contribute to a better understanding of Language Virtual Laboratories and their benefits in improving the quality of teaching and learning in higher education.

2 Methods

Study Design

This study examines language virtual laboratories worldwide. This method analyzes publishing variables including citations, authors, journals, institutions, nations, and keywords. This study uses bibliometric analysis, a popular statistical method. This technique works well for analyzing large amounts of academic data in certain disciplines (Donthu et al, 2021). The present study uses bibliometric analysis to show language virtual laboratory trends.

Data Collection

A total of 524 documents were obtained from the Scopus database (http://www.scopus.com/). Scopus was chosen because it includes a broader range of document types than other scholarly databases (Mongeon & Paul, 2016). Scopus covers a wide range of subjects essential to higher education internationalization and gives quick access to bibliographic data (Zupic & Cater, 2015). Furthermore, Scopus covers more educational subjects than other databases such as Web of Science (WoS) (Ghani et al., 2022). As a result, using Scopus allows researchers to explain subjects that may not be present in WoS.

Metadata was collected on August 4, 2023, with a publication year range of 2012-2022. All document categories were considered (for example, books, book chapters, conference reviews, reviews, editorials, and brief surveys). The objective of this article was to provide a more in-depth understanding and a clearer perspective of the subject during the last decade. To find these articles, use the following primary search terms: TITLE-ABS-KEY ("language*" and "virtual*" and "laboratory*").Data Analysis

The first two authors searched the Scopus database for papers and examined the chosen study independently. The study started with a review of the titles, abstracts, and keywords. The documents that fit the criteria were then gathered. The second group of authors extracted data independently. Each document was also classified according to its author, publication year, publishing venue, institutions, nations, and citation count. Among the 524 resources were 640 conference papers, 370 journal articles, and 106 other document categories.

Data were exported in CSV and RIS formats. Data analysis was calculated in Excel. Most of the data were percentages and frequencies. VOSviewer (https://www.vosviewer.com/) was used to visualize bibliometric networks (Jan & Waltman, 2021). Analysis results were displayed in tables and network visualization maps. Article numbers were represented by node sizes and collaboration intensity by line thickness. Notably, published texts' often co-occurring keywords were color-coded and clustered.

3 Findings and Discussion

Publication Trend and Citation of Results

According to the research, a total of 524 papers were published between 2012 and 2022. Figure 2 shows the annual publication count and cumulative citations for the virtual language laboratory over the years.

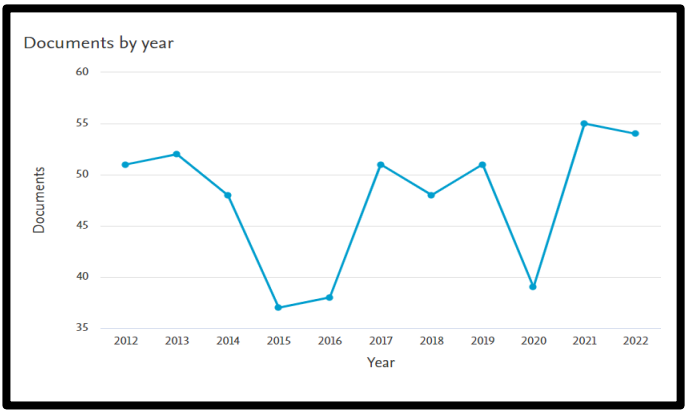

Fig. 1. Distribution of Publications on Virtual Language Laboratory Based on Year

In 2012, 51 documents were published on the topic of virtual language laboratories in higher education. There were 226 documents produced throughout the first five years (2012-2016). The number of studies in this topic increased significantly over a five-year period (2017-2021), totaling 244 documents. The total number of publications reached 54 as of 2022 (the year this research was conducted). In terms of citation count, this trend has steadily risen year after year, aligning with an increase in publication volume in this domain. Until now, the total number of citations has been 2953, equivalent to an average of 5.63 citations per article. The development reflects the increasing attraction of the virtual language laboratory in the field of higher education, which is attracting the attention of a wider range of researchers.

Most Cited Documents

Table II shows the ten most frequently mentioned documents over the years.. Regarding the documents based on the highest citation count, the article by de Jong et al. (2014) titled "Innovations in STEM education: the Go-Lab federation of online labs" rank the 1st position with 195 citations. The two most cited articles are "PhysiCell: An open source physics-based cell simulator for 3-D multicellular systems," by Ghaffarizadeh et al. (2018), with 185 citations, and the work of Lin et al. (2014) entitled "Wireless and wearable EEG system for evaluating driver vigilance," ranking the third position with 168 citations.

Table 1. Top 10 Most Cited References

Author(s)	Document Title	Source	Citation
de Jong et al (2014)	Innovations in STEM education: the Go-Lab federation of online labs	Smart Learning Environments	195
Ghaffarizadeh , et al (2018)	PhysiCell: An open source physics-based cell simulator for 3-D multicellular systems	PLoS Computational Biology	185
Lin et al, 2014	Wireless and wearable EEG system for evaluating driver vigilance	IEEE Transactions on Biomedical Circuits and Systems	168
Tawfik et al, 2013	Virtual instrument systems in reality (VISIR) for remote wiring and measurement of electronic circuits on breadboard	IEEE Transactions on Biomedical Circuits and Systems	138
Darekar et al, 2015	Efficacy of virtual reality-based intervention on balance and mobility disorders post-stroke: A scoping review	Journal of NeuroEngineering and Rehabilitation	119
Boada et al, 2015	Using a serious game to complement CPR instruction in a nurse faculty	Computer Methods and Programs in Biomedicine	62
Chacón et al, 2015	EJS, JIL Server, and LabVIEW: An Architecture for Rapid Development of Remote Labs	IEEE Transactions on Learning Technologies	56
Bermúdez-Ortega et al (2015)	Remote Web-based Control Laboratory for Mobile Devices based on EJsS, Raspberry Pi and Node.js	IFAC-PapersOnLine	51
Chen et al (2012)	Application of discrete element method to Superpave gyratory compaction	Road Materials and Pavement Design	50
Abdulwahed et al (2013)	Developing the TriLab, a triple access mode (hands-on, virtual, remote) laboratory, of a	Computer Applications in	45

Author(s)	Document Title	Source	Citation
	process control rig using LabVIEW and Joomla	Engineering Education	

This finding clearly shows that the number of researchers specifically exploring the integration of virtual laboratories within the context of language instruction in higher education institutions is relatively limited. While there exist several publications reflecting the potential and utilization of virtual laboratories in this field, the measured citation counts and achieved levels of attention still signify a constraint in terms of in-depth research focus. Consequently, significant opportunities persist for researchers to delve further into this aspect, aiming to optimize the role of virtual laboratories in enhancing the quality of language education within higher education.

Most Productive Sources

In this study, a compilation of 524 documents was published across 87 different publishing journals. Only six sources produced 10 or more documents. The six most productive sources are detailed in Table 2.

Table 2. Top 10 Most Productive Sources

Source	Numbers of documents
Journal of Physics Conference Series	18
Advances In Intelligent Systems And Computing	16
Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	12
Ceur Workshop Proceedings	11
Applied Mechanics And Materials	11
IFAC Papersonline	10

Therefore, these six sources have published a total of 78 documents. The Journal of Physics Conference Series has the highest number of published articles, comprising a total of 18 publications. The journal "Advances In Intelligent Systems And Computing" has achieved the second position, publishing a total of 16 papers. The topic under consideration is Lecture Notes in Computer Science, which includes a subseries as well. The publication series known as Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics holds the third position in terms of ranking, with an overall output of 12 works. Tables

Locate tables close to the first reference to them in the text and number them consecutively. Avoid abbreviations in column headings. Indicate units in the line immediately below the heading. Explanations should be given at the foot of the table, not within the table itself. Use only horizontal rules: One above and one below the column headings and one at the foot of the table (Table rule tag: Use the Shift-minus key to actually type the rule exactly where you want it). For simple tables use the tab key and not the table option. Type all text in tables in small type (Table text tag). Align all headings to the left of their column and start these headings with an initial capital. Type the caption above the table to the same width as the table (Table caption tag). See for example Table 2.

Most Productive Institutions

A comprehensive spectrum of 161 institutions worldwide has contributed to the discourse on virtual language laboratories. Universidad Nacional de Educacion a Distancia emerges as the most prolific among the top 10. Universidad de Murcia secures the second position with 10 papers, followed by Slovak University of Technology in Bratislava and Macquarie University, both presenting 6 papers. The institutions with the highest productivity are shown in Table III.

Table 3. Top 10 Most Productive Institutions

Institution	Number of Documents
Universidad Nacional de Educacion a Distancia	23
Universidad de Murcia	10
Slovak University of Technology in Bratislava	6
Macquarie University	6
Chinese Academy of Sciences	5
National Technical University Kharkiv Polytechnic Institute	5
Universitatea Transilvania din Brașov	5
Universitat Politécnica de Catalunya	4
SRM Institute of Science and Technology	4

Most Productive Countries

In terms of countries, authors from 74 distinct countries have contributed to the discourse surrounding virtual language laboratories. A total of 16 countries have made contributions in at least 10 documents, while 58 countries have

provided contributions to fewer than ten documents. Table IV presents the leading 10 countries/regions in this field.

Table 4. Top 10 Most Productive Countries

Countries	Number of Documents
United States	65
China	61
India	50
Spain	48
Russian Federation	29
Italy	24
Brazil	19
Australia	16
Indonesia	16

Table IV shows that the United States ranks in top position with 65 publications, followed by China (61), India (50), and Spain (48). These three countries underscore their prominent roles within this domain.

Most Influential Authors

The ten most prolific authors in the publications concerning virtual language laboratories from 2012 to 2022 are presented in Table V.

Table 5. Top 10 Most Influential Authors

Writers	Numbers of documents
Esquembre	11
Dormido	8
Galan	8
Heradio	8
Cassidy	6
De La Torre	6
Kupriianov	5
Estival	4
Samoila	4

Esquembre is regarded as the most prolific author with 11 publications. Dormido, Galan, and Heradio is the second position with 8 articles each, thereby highlighting their active roles within this field. As illustrated in the table, the most cited documents are authored by writers from Western countries/regions.

Map of Publication Theme

Upon processing the data from Scopus utilizing VOSviewer software, results of bibliometric analysis covering 14,478 terms was obtained. From this outcome, the closest 275 terms were selected and subsequently presented in Figure 2.

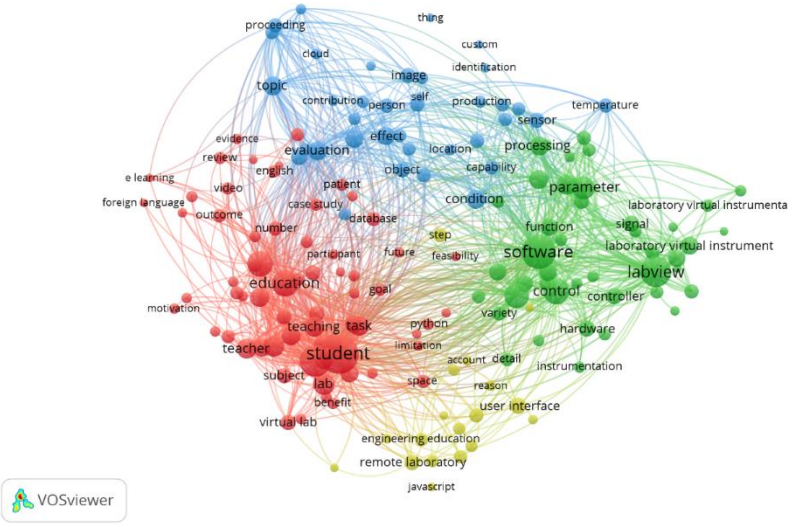

Fig. 2. Map of Publication Themes

The Circles Network Visualization results generated using VOSviewer software show the existence of four distinct thematic clusters within publications related to virtual language laboratories. These themes are outlined as follows:

1. The "Virtual Laboratory Learning" Theme (in red) consists of 66 items, including keywords such as English, foreign language, physics, education, and e-learning.
2. The "Laboratory Systems" Theme (in green) encompasses 44 items, featuring keywords like Labview software, virtual instrument, data acquisition, hardware, and control system.
3. The "Implementation Techniques" Theme (in blue) comprises 37 items, encompassing keywords such as network, investigation, production, location, and construction.

4. The "Laboratory Elements" Theme (in yellow) encompasses 18 items, featuring keywords like Java, JavaScript, Metlap, user interface, and account.

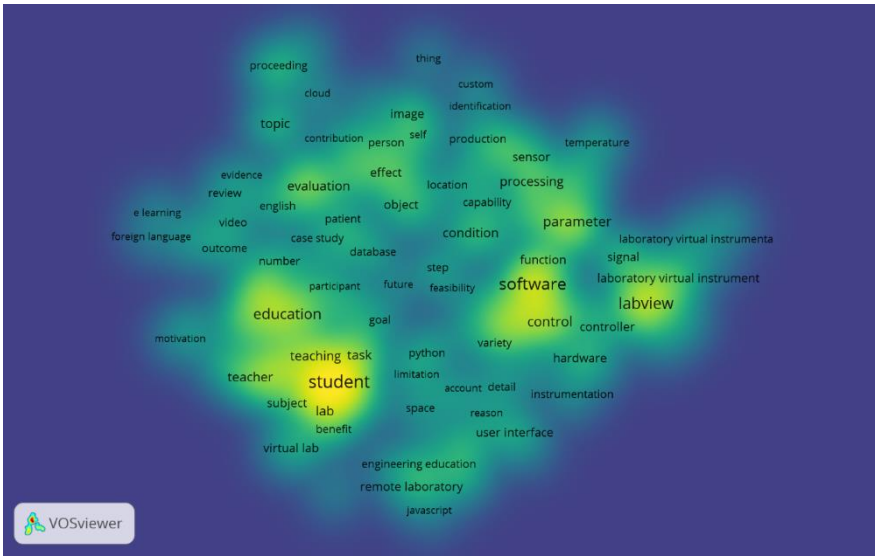

Fig. 3. Visualization of VOSviewer Using a Brightness Dim Map

Figure 3 shows the density visualization produced by the bibliometric study using VOSviewer software. The density or concentration of study themes is shown using a bright yellow color scale in this graphic. Increasing brightness implies substantial investigation into the relevant issue, whilst decreasing brightness indicates little research interest. Remote laboratory, foreign language, English, and feasibility, for example, have the ability to serve as reference points for future research activities and developing subjects for examination. These unstudied themes provide important opportunities for future research projects and serve as basic resources for the advancement of future research projects.

4 Conclusion

The most productive instituions and countries in Language Virtual Laboratory publications provide valuable information as well. The Universidad Nacional de Educacion a Distancia is the most productive institution in terms of disseminating articles on this topic. Countries like the United States, China, and India also dominate in terms of publication volume, showing significant contributions from all around the world. Esquembre emerges is wellknown among the most productive authors, with a large number of works. This finding shows that various researchers are actively contributing to the production and diffusion of information in the field of Language Virtual Laboratories.

Studies such as that by Chien et al. (2020) indicate that using a language virtual laboratory system to practice English speaking, assessed by classmates, can enhance English speaking abilities, motivation, and critical thinking skills. Similarly, research by Sun et al. (2018) found that immersing students in a virtual language environment positively impacted their higher-level thinking skills.

Furthermore, the potential of 3D learning objects and blended learning environments, which combine virtual and real-world reality techniques, requires more study in future research. This method has the potential to create dynamic, low-cost, multi-sensory learning experiences (see, for example, Campbell et al., 2016; Mangina, 2017). Such environments have the ability to provide high-quality learning experiences by moving beyond passive traditional teaching and learning environments and actively engage learners in a multisensory digital learning ecosystem (Mangina, 2017).

The use of VOSviewer software to visualize publishing themes provides an understanding of the key research focuses. Virtual laboratory learning, laboratory systems, implementation approaches, and laboratory elements are divided into four theme clusters. These themes highlight several factors that have piqued the interest of scholars in the field of Language Virtual Laboratories. Overall, this bibliometric analysis is beneficial to academics, educators, and researchers interested in the development of Language Virtual Laboratories in higher education. These findings can serve as a basis for further growth in this subject and provide guidance for future research that improves language learning quality in higher education using Language Virtual Laboratories.

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