SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Trends Virtual Laboratory for Practical Learning in Vocational Education

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ARTICLE INFO

Article history:
Received 30 November 2023
Received in revised form 19 April 2024
Accepted 16 July 2024
Available online 10 August 2024

Keywords:

Virtual laboratory; Vocational education
TVET; Bibliometrics

ABSTRACT

Using virtual laboratories for practical learning in vocational education has significantly increased in recent years. This study aims to analyse virtual laboratory research trends for practical learning in vocational education through bibliometric analysis by taking data from Scopus (intro/issue). The method used in this bibliometric journal article is the bibliometric method. This research step consists of (i) determining search keywords, (ii) collection of publication data, (iii) bibliometric data processing, (iv) bibliometric data mapping, and (v) data analysis. The search keywords used to collect data were "Virtual laboratory," "Vocational," and "Education." There are 31 articles indexed by Scopus from 2002 to 2023. From 2019 to 2023, research on virtual laboratories in vocational education has increased. This is because access to computer technology, the internet, and mobile devices is increasingly widespread, and a surge in technology use occurred during the COVID-19 pandemic. The results of the bibliometric mapping analysis show there are 24 terms grouped into 3 clusters. The terms virtual laboratory and vocational education are related in research. Virtual laboratories help overcome problems in vocational education, especially for productive vocational subjects such as working on dangerous equipment.

1. Introduction

Vocational education is increasingly adopting advanced technology to improve student learning experiences [1-6]. One technology that is increasingly getting attention is the virtual laboratory [7]. In an era where information and communication technology are developing rapidly, virtual laboratories are an innovative solution for providing practical and experimental experiences in a vocational education environment [8]. The trend of using virtual laboratories in vocational education has shown a significant increase in recent years, with many vocational institutions and programs adopting this technology to expand access, increase efficiency, and improve the quality of learning [9].

The use of virtual laboratories in vocational education provides easy access to online practicums and allows students to learn practical skills in a safe and controlled way [10-14]. Virtual laboratories

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https://doi.org/10.37934/araset.50.1.264275

provide a simulation platform that allows students to conduct experiments without risk to equipment or the physical environment [15,16]. That way, students can develop technical skills in areas such as engineering, computer science, healthcare, and other industries without having to rely entirely on physical laboratories that may be limited [9,17].

Virtual laboratories can also increase student involvement and interest in vocational learning [18]. The interactive learning experiences offered by virtual laboratories [19], such as attractive graphic visualizations and challenging simulations, can motivate students to be more actively involved in learning [20,21]. In addition, integrating simulation, virtual reality, and augmented reality technology in virtual laboratories provides a learning experience close to the actual work environment, helping prepare students to enter the industrial world with relevant and ready-to-use skills [22].

Currently, there has been much research regarding the application of virtual laboratories in vocational education for practical learning of micro power plants [23], vocational productive learning using augmented reality [24], vocational learning for conceptual understanding of electrical circuits in secondary vocational-technical education [25], research on the development of virtual laboratories with a problem-based learning model [26] and research on the influence of virtual laboratories on the knowledge of medical laboratory engineering students [27]. However, no research has discussed the trend of virtual laboratory research in vocational education by taking data from Scopus. Therefore, this research aims to analyse virtual laboratory research trends in vocational education through bibliometric analysis using Scopus data. This study can add new information regarding bibliometric analysis [28-40].

2. Methodology

The method used in this bibliometric journal article is the bibliometric method, which aims to analyse trends regarding virtual laboratories in vocational education. Detailed information for the use of bibliometric is shown elsewhere [41]. There are five steps taken to carry out bibliometric analysis as shown in Figure 1, namely

i. determining search keywords
ii. collection of publication data
iii. bibliometric data processing
iv. bibliometric data mapping
v. data analysis

Research data was taken on April 9, 2024. Research data was obtained from the Scopus database from 2002 to 2023.

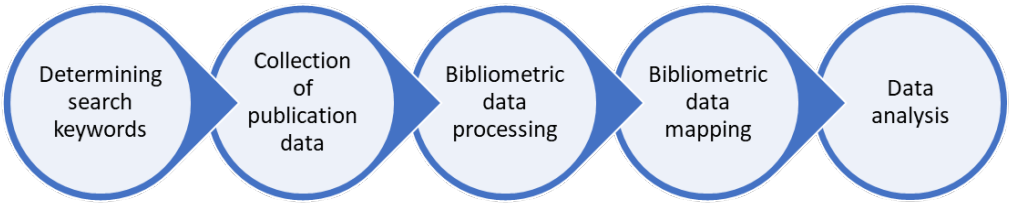

Fig. 1. Research procedure

i. Determining Search Keywords: The search keywords used to collect data are "Virtual laboratory," "Vocational," and "Education." The selection of keywords is important to ensure the relevance of the data collected to the research focus.
ii. Publication Data Collection: Publication data is collected from the Scopus database. The year range used in data collection is 2002 to 2023. This broad period allows us to see trends over a significant period.
iii. Bibliometric Data Processing: After publication data has been successfully collected from the database, the next step is to carry out bibliometric data processing. This includes organizing, analysing, and filtering data according to research needs.
iv. Bibliometric Data Mapping: Processed bibliometric data is then used to create a map related to existing trends and patterns in research regarding virtual laboratories in vocational education using the VOSviewer application. This mapping helps in better visualization and understanding of the data.
v. Data Analysis: The final step is to analyse the bibliometric data that has been mapped. This analysis aims to draw conclusions and present relevant findings regarding virtual laboratory trends in vocational education based on the data that has been collected and processed.

3. Results and Discussion

3.1 Research Developments

The search results show that 31 articles regarding virtual laboratory research in vocational education have been published and indexed by Scopus. Figure 2 shows the development of research regarding virtual laboratories in vocational education. The number of publications per year is seven documents in 2023, 3 documents in 2022, 3 documents in 2021, 4 documents in 2020, 3 documents in 2019, 3 documents in 2018, 1 document in 2017 and 2016, 2 documents in 2015, 2014, 2013, 2012 and 2011 there were no publications, 2010 there were 1 document, 2009 there were no publications, 2008 there were two publications, 2007 there were no publications, 2006 and 2005 there were 1 document, 2004 and 2003 there were no publications, and 2002 there were two publications.

Based on the data shown in Figure 2, it is known that the development of research regarding virtual laboratories in vocational education at Scopus began to occur in 2002. From 2002 to 2023, the development of publications fluctuated between 2022 and 2010. Meanwhile, during the four years, namely 2011 - 2014, there have been only a few publications on this theme. 2015, there was another increase, but until 2018, there was a decline in publications again. From 2019 to 2023, research regarding virtual laboratories in vocational education has increased. A significant increase will occur in 2023 when compared to previous years.

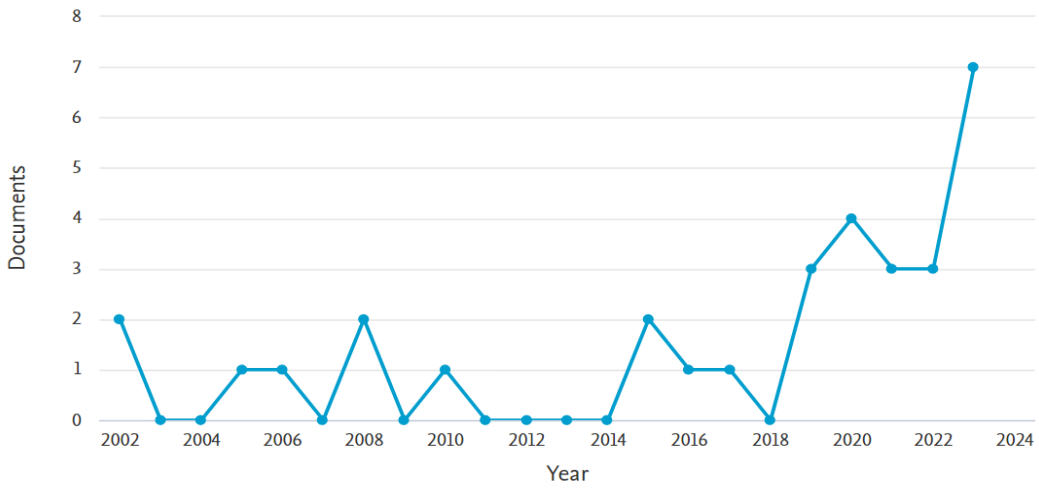

Fig. 2. Development of research regarding virtual laboratories in vocational education

Virtual laboratories were first introduced in 1986 by Larry Smarr and Tom DeFanti from the National Centre for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign with the term Cave Automatic Virtual Environment (CAVE), namely a 3D projection space that allows users to interact. With a full-scale virtual environment [42]. CAVE is one of the early innovations in virtual laboratory technology that utilizes computer visualization to simulate laboratory experiences.

In addition, the term "virtual laboratory" is also often associated with using computer simulations to simulate experiments or scientific processes in a virtual environment. The use of this technology has grown since the late 1980s and early 1990s in various scientific fields, including physics, chemistry, biology, and engineering, and with the advent of the internet in the mid to late 1990s, virtual laboratories also developed into online platforms that allow open access to online simulations, data, and virtual experiments. This opens the door to remote collaboration and distance learning using virtual laboratory technology.

Although virtual laboratories have been known for a long time, based on the data obtained in this research, the development of research on virtual laboratories in vocational education indexed by Scopus is proliferating from 2019 to 2023. This is because access to computer technology, the internet, and mobile devices is increasingly widespread [43]. Apart from that, during those years, the Covid-19 pandemic occurred. A surge in technology use occurred during the COVID-19 pandemic; for example, online learning became a regular activity [44-46]. This has an impact on the application of virtual laboratories to be essential to facilitate practical learning and remote experiments [16].

Figure 3 shows the ten countries with the most contributions to writing articles about virtual laboratories in vocational education indexed by Scopus.

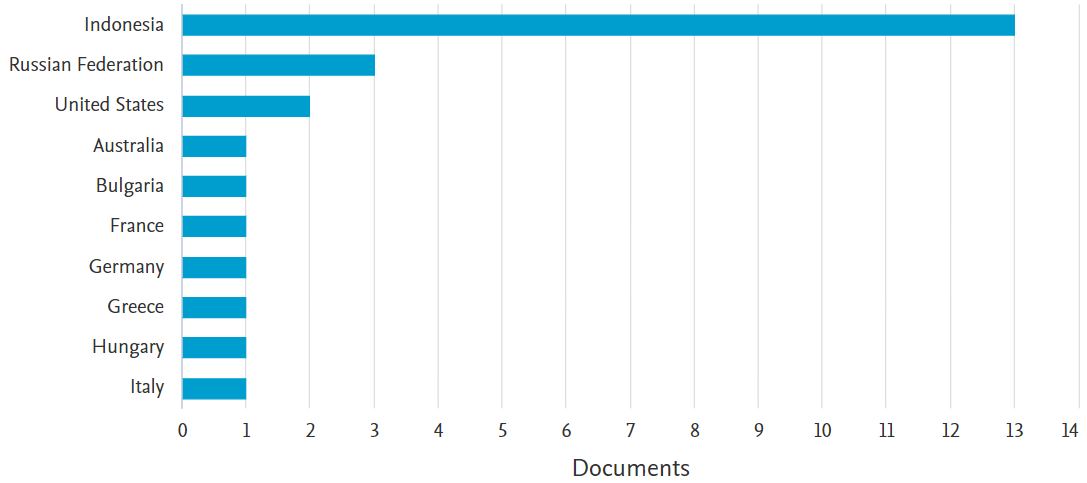

Fig. 3. Contribution to Scopus publication articles based on country

Meanwhile, Figure 4 shows the ten affiliates with the most contributions to writing articles about virtual laboratories in vocational education indexed by Scopus. Based on the data in Figure 3 shows that Indonesia is in first place with the highest number of contributions to the publication of articles regarding virtual laboratories for vocational education on Scopus, with a total of 13 documents. The second position is the Russian Federation, with three documents; the third is the United States, with two documents. Meanwhile, Australia, Bulgaria, France, Germany, Greece, Hungary, and Italy have 1 document.

The results of the number of contributions to the publication of articles regarding virtual laboratories for vocational education in Scopus by country are directly proportional to the affiliates who contributed to the writing and publication of articles on this theme in Scopus. One of the ten affiliates with the highest number is the Indonesian Education University from Indonesia, which occupies the first position with four documents, and Sebelas Maret University from Indonesia with three documents. In the following positions, there is the Study Program of Information Engineering at Ohio University from the United States, Bina Nusantara University from Indonesia, and Padang State University from Indonesia, which has two documents. Meanwhile, positions 7 to 10 with 1 document are Hildebrand Technology Limited, IFMA, 🇩🇪ESTA-Bildungswerk, and Gradoservice LLC.

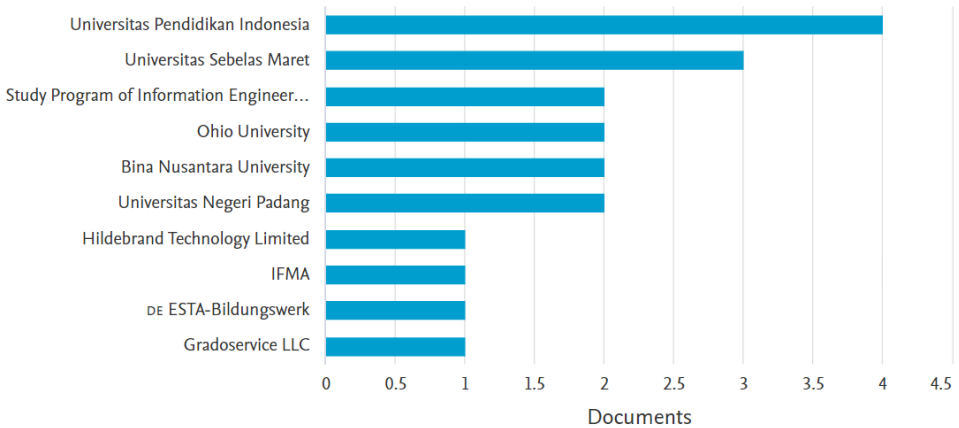

Fig. 4. Contribution to Scopus publication articles based on affiliation

3.2 Bibliometric Analysis Mapping

Mapping bibliometric analysis was carried out in this study. The mapping process is carried out using the VOSviewer application. Figure 5 shows a visualization of the research bibliometric analysis network regarding virtual laboratories for vocational education. Network visualization shows the relationship of one term to other terms often used in research articles and laboratories for vocational education. The bigger the circle (node) in the image, the more often the term is found [47]. There are 249 terms from 31 articles based on bibliometric mapping analysis. The minimum number of occurrences of terms is two times, so 49 terms were found. After that, we filtered the terms found so that were 24 terms grouped into 3 clusters.

Cluster 1 has a red node colour; there are 11 terms, namely ability, application, augmented reality, education, high cost, laboratory, learning, student practice, study, virtual laboratory, and virtual laboratory medium. Cluster 2 has a green node colour with seven terms: covid, distance, higher education, learning process, medium, quality, and technology. Meanwhile, Cluster 3 has a blue node colour with six terms: class, electronic educational resource, online learning, system, training, and vocational education.

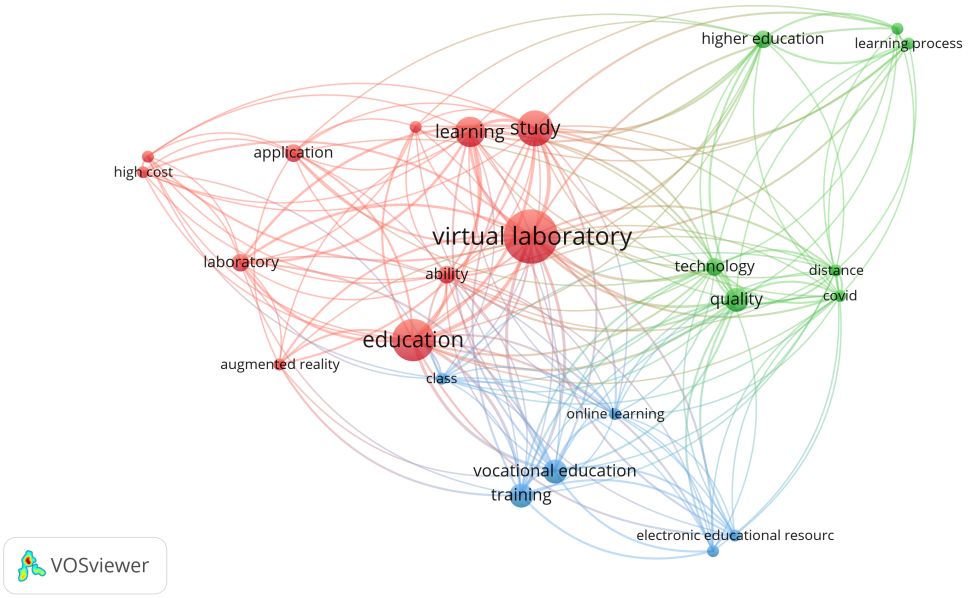

Fig. 5. Network visualization

Based on Figure 5, it is known that the terms with the highest number of occurrences and total link strength are virtual laboratory, education, learning, study, and vocational education. Total link strength shows the strength of the relationship between one term and another [48]. Meanwhile, total occurrences show the number of discoveries of the term from the publication of bibliometric data used in this research. Additionally, virtual laboratories and vocational education have research connections with each other. A depiction of the relationship between virtual laboratories and vocational education is shown in Figure 6.

Virtual laboratories can help overcome various problems in vocational education, especially for productive vocational subjects such as work on dangerous equipment, including very high voltage or expensive equipment, which is better carried out through simulation [49,50]. Virtual laboratories can support practical activities in interactive, dynamic, animated, and virtual environments so that they are not dull and can support the user's desire to learn and understand productive subject matter in

vocational education [51]. Therefore, much research has been conducted regarding the use of virtual laboratories in vocational education [23,24,26,52-54].

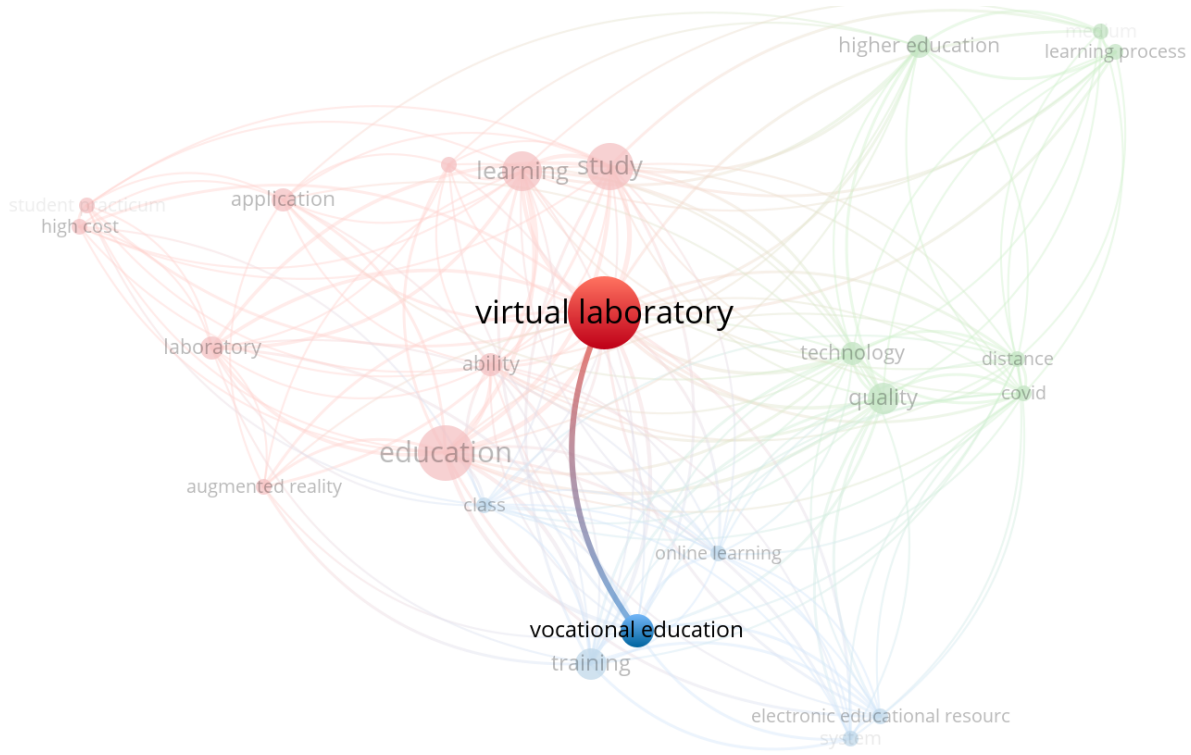

Fig. 6. The relationship between the term's virtual laboratory and vocational education

Figure 7 shows an overlay visualization of research regarding virtual laboratories in vocational education. Overlay visualization is a way to depict a network where each item, term, or node is identified with a different colour. There are two methods for colouring nodes in an overlay visualization, where the term score at each node determines the node colour. By default, colours run from blue (lowest score) to green and then yellow (highest score). Figure 7 shows that the colour boxes show how scores are mapped into specific colours. The colour shows the average score of publications per year, with the size of the node depending on the number of appearances. Figure 7 shows that the terms student practice, high cost, higher education, medium, learning process, quality, distance, covid, ability, class, electronic educational resource, and the system appeared on average in 2023. This means that these terms have been widely used in recent years of research regarding virtual laboratories in vocational education.

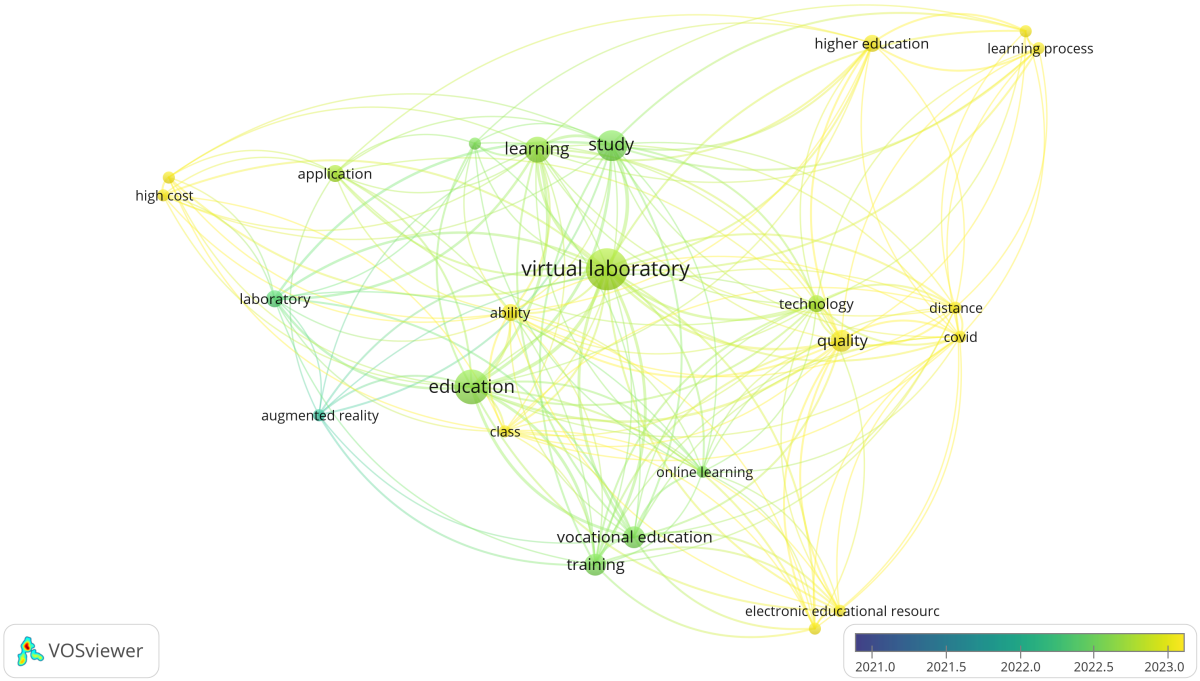

Fig. 7. Overlay visualization of air brush make up technology research

These terms correspond to virtual laboratories' benefits in learning, especially in vocational education. Virtual laboratories allow students to conduct practicums online from anywhere, even if the school still needs complete physical laboratory facilities [55]. Virtual laboratories can simulate environments and situations that are difficult or impossible in a physical laboratory. Virtual laboratories can be used as learning media to improve vocational student learning outcomes [53,54,56].

4. Conclusions

This research discusses virtual laboratory research trends in vocational education through bibliometric analysis. Based on bibliometric analysis, you can find out how research developments or trends are occurring, especially regarding virtual laboratories in vocational education. Analysis results based on Scopus annual report: From 2002 to 2023, the development of publications fluctuated, but from 2019 to 2023, there was an increase in the number of publications on Scopus. The country with the highest number of articles contributed to this research is Indonesia, and the affiliate with the highest number of contributions is the Indonesian Education University. Several terms are identified in this bibliometric analysis, of which 24 are grouped into 3 clusters. The terms with the highest number of occurrences and total link strength are virtual laboratory, education, learning, study, and vocational education. The implication is that the virtual laboratories can help overcome various problems in vocational education, especially for productive vocational subjects such as work on dangerous equipment, including very high voltage or expensive equipment, which is better carried out through simulation.

Acknowledgement
This research was not funded by any grant.

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