

VOSviewer application within the scope of bibliometric analysis: Literature review on the use of virtual laboratories in education

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ABSTRACT

Scientific research is acknowledged as the main reason for producing information, and interdisciplinary interactions shape it. Within this broad and dynamic field, understanding scientific literature, exploring specific topics, and monitoring research trends is an important requirement. Bibliometric analysis has emerged as a powerful tool to achieve this goal. This article aims to understand the connections and trends in the literature on the virtual laboratory, analyze and visualize large data sets using the bibliometric analysis tool VOSviewer to understand the evolution of scientific research and examine interdisciplinary interactions. VOSviewer bibliometric analysis program offers researchers the opportunity to examine many connections in large data sets. For example, by using basic analysis techniques such as co-author and citation information, similarity of use of concepts within the study, these partnerships can be detected in many areas such as source(s), author(s) and references. In the method and application phase was made by analyzing nearly two thousand studies on the relevant subject area from both Google Scholar and Web of Science databases, using the scientific mapping approach in accordance with the systematic of the current research. The research results show that the research with the highest citation network was carried out by Gunawan, Herga, Dinevski, Manyilizu, and Majuto Clement. Whereas the basic concepts representing the studies in the field are education in chemistry, molecular biology, and technology. The results obtained from the study are aimed to help both the VOSviewer bibliometric analysis program and virtual laboratory studies.

Introduction

It is known that knowledge is accumulating regularly in today's environment of increasing adoption of information and communication technology and that we must take more benefit from this accumulation. With globalization, the circulation of information and the need to benefit more from this information have brought about the development of information access technologies. Education is one of the disciplines that is affected positively or negatively by all developments in

the world. Especially today, education is greatly affected by rapidly developing technology and universal events that can affect the whole world. The most obvious evidence of this is centered around technology distance learning method, whose application has increased significantly since the recent COVID-19 outbreak (Özdemir & Önder-Özdemir, 2023). Internet-based teaching can be defined as an individualized teaching process that enriches teaching environments by offering rich communication options and easy access to information and is based on the learner's construction of knowledge (Albayrak & Albayrak, 2016; Şahan, 2005).

It is now feasible to develop flexible and interactive remote learning environments because of recently developed technology (Tüzün, Bilgiç, Kalaycı, Çınar, Akıncı, Yıldırım & Yüksel, 2011). The environments in question appear to be synchronous and asynchronous communication tools and applications. One of the most important of these applications is the virtual laboratory technique. A virtual laboratory is a computer-enabled application area which provides opportunities for interactive, real-time simulation of experiments that need to be finished in order for teachers to get practical experience in teaching (Akin & Karaköse, 2003; Martins, Gonçalves & Branco, 2024). Virtual laboratory applications have become an important subject of research in the field of education.

As with all other fields, the scientific community and scientific literature have been profoundly impacted by the rapid advancement of technology, making science an immediately evolving, and increasingly complicated field. This development has influenced researchers in many ways. Although it offers intensive content to researchers, it also brings with it some difficulties in discovering new information and gaining an interactive perspective on existing research. Scientific literature has made extensive information that has been acquired through technological advancements available in a variety of visual ways. As a significant tool for academics doing thorough and systematic data set evaluations of scientific literature, bibliometrics is increasing in importance (Bilad, 2022). These analyses aim to map scientific knowledge broadly, as well as identify space in literature, pioneering works, and trends in scientific domains. Bibliometrics examines keywords, citations, and other significant indicators to provide academics with an extensive view. In recent years, there has been a significant increase in the growth rate of scientific literature, thanks to the ease of access to information and technological developments. This situation has revealed the need for researchers, scientists, and decision-makers to use effective tools and methods in order not to get lost in this sea of big data (Al & Çoştur, 2007; Baker, 2010). Bibliometrics is used in many different areas in the academic world. For example, the number of citations in a researcher's publications is considered an important indicator in determining the academic impact and reputation of that researcher. Additionally, bibliometric analyses can be used in strategic decision-making processes such as identifying research trends, monitoring the development of fields, and identifying potential collaboration opportunities. VOSviewer, one of the bibliometric analysis tools, stands out as a powerful tool for analyzing and visualizing large data sets in scientific literature. VOSviewer is a program equipped with scientific text mining and visualization tools and provides comprehensive analysis to understand connections and trends in literature. VOSviewer stands out as a combination of literature analysis, knowledge mining, and visualization. It is also a powerful tool for exploring interactions and trends in literature in interdisciplinary studies and on different research topics. VOSviewer is a scientific mapping program designed for visualizing bibliometric networks. It can perform many bibliometric network analyses, such as keyword co-occurrence analysis and co-authorship analysis, as well as visualization of citation networks. Bibliographic data from databases like Dimension, Lens, Scopus, and Web of Science as well as reference manager applications like EndNote, RefWorks, and RIS can be made use of to create a bibliometric map of a certain area (Van Eck & Waltman, 2022). The program offers three different visualizations of a map with the

data in question: network, layer, and density. VOSviewer creates relationship networks using co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation relationships. These networks can be made up of scientific publications, scientific journals, researchers, research institutes, nations, keywords, and/or concepts. The fundamental analysis of the software is similarly comprised of these relationships. When the structure of the VOSviewer application is examined in Figure 1, it is seen that it consists of 4 basic panels and all the features are located in the panels. These panels consist of the main panel (1), information panel (2), overview panel (3) and action panel (4), respectively (Van Eck and Waltman, 2010).

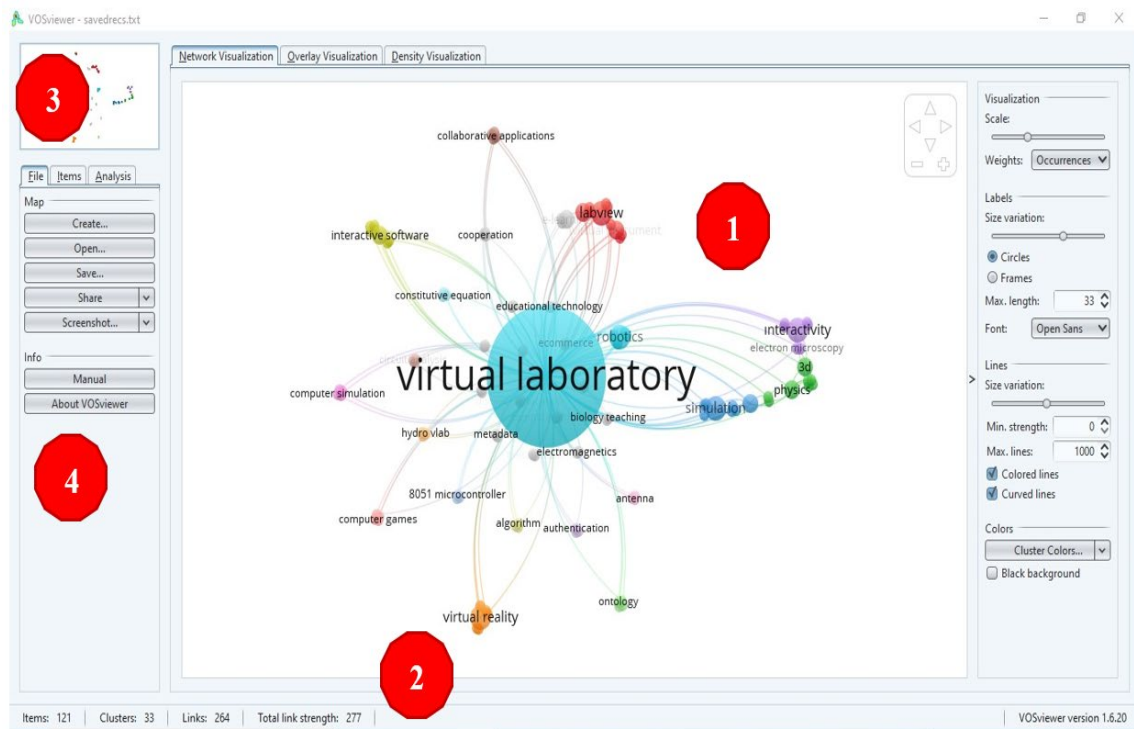


Figure 1 Panels and tabs of the VOSviewer program

The analytical tools provided by VOSviewer offer researchers important insight into identifying significant touchpoints in the literature, tracing of keywords, and showing linkages between studies within a certain topic or field (Van Eck & Waltman, 2011). The data from studies on virtual laboratories in education will be examined in our research, with a focus on how useful the VOSviewer tool is for the analysis and visualization of scientific research (Putri, Soleh, Saregar, Anugrah & Susilowati, 2021). With all of this information in mind, the aim of this research is to investigate multidisciplinary interconnections, analyse and visualize massive data sets using VOSviewer, a bibliometric analysis tool, and comprehend the relationships and patterns in the literature on the virtual laboratory. The significance of virtual laboratory applications in education and their place in the literature are the main topics of this article.

Method and utilization

Today, a large amount of research and publications are carried out in the field of education, making it difficult for educators and researchers to access and analyse information. In this context, bibliometric analysis has become an important tool for evaluating large data sets and measuring the impact of scientific research in the field of education. In this study, which tries to explain the use of the VOSviewer program in the context of virtual laboratory research, the bibliometric mapping approach was used. Bibliometric mapping allows researchers to analyse studies

conducted in a specific field through authors, regions, organizations, citations, co-citations, and more details for refining (Abdullah, 2021). Bibliometrics sheds light on the process of scientific discovery through the quantitative analysis of scientific publications and citations. In this way, the impact, popularity, and scientific contribution of research can be measured objectively. At the same time, bibliometrics provides an important way for researchers to track studies on specific topics and gain an in-depth understanding of the relevant literature. With this method, researchers can identify developments, key concepts, leading researchers, and the most influential publications in the literature of a field. Additionally, bibliometric analyses guide in determining future research directions by tracking trends and changes in a research field. In this way, researchers have the opportunity to direct their studies to the most current and effective points of the subject (Effendi, Irwandani, Anggraini, Jatmiko, Rahmayanti, Ichsan & Rahman, 2021).

An online scan of 2000-December 2023 was carried out in the WoS (Web of Science) and Google Scholar database. Searches were conducted using the Google Scholar and Web of Science search engines within the parameters of the study. After the studies were purified from repetitive studies and studies outside the scope of the research through further screening, approximately two thousand studies were reached and downloaded and saved in file formats with various extensions such as CSV, RIS, and BibTeX. While limiting the inclusion of studies in the database, care was taken to include studies examining the use of virtual laboratory applications, especially in the field of education. In this context, main fields of study such as health and engineering were excluded from the database, and studies based on "education" were included. In line with the purpose of the research, the general view of virtual laboratory research using the VOSviewer program was mapped with bibliographic matching, co-citation, co-authorship, concept association, and citation network analysis techniques within the framework of the application.

Analyses and findings regarding bibliometric mapping

The conclusions reached through the research, which involved looking at Google Scholar and Web of Science search engine results based on multiple features, are explained below.

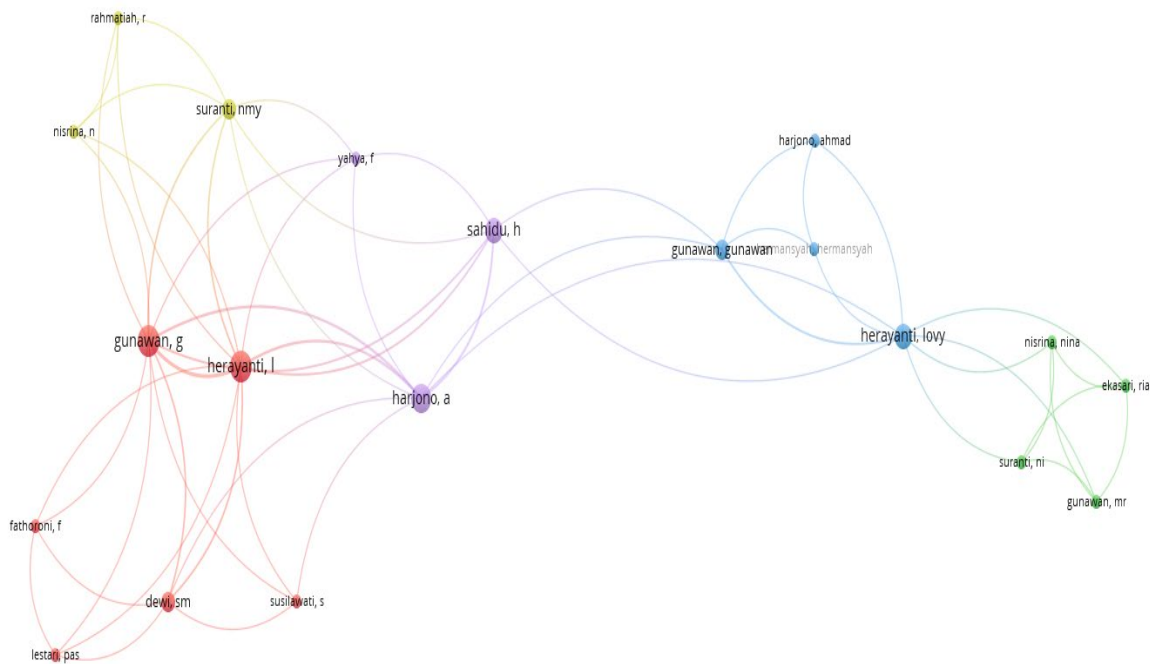


Figure 2 Authors connection with co-authorship Google Scholar

The literature database on virtual laboratory use in education is analysed in the VOSviewer program via the RIS file via the Google Scholar search engine. In this context, nearly a thousand data were analysed and visualized. Figure 2 examines the connection between co-authorship and authors. As a result of the analysis, approximately 20 relevant links were identified. The obtained connections were examined in the network visualization pane. It is seen that the distribution is generally shaped on the co-authors of Gunawan and Heryanti.

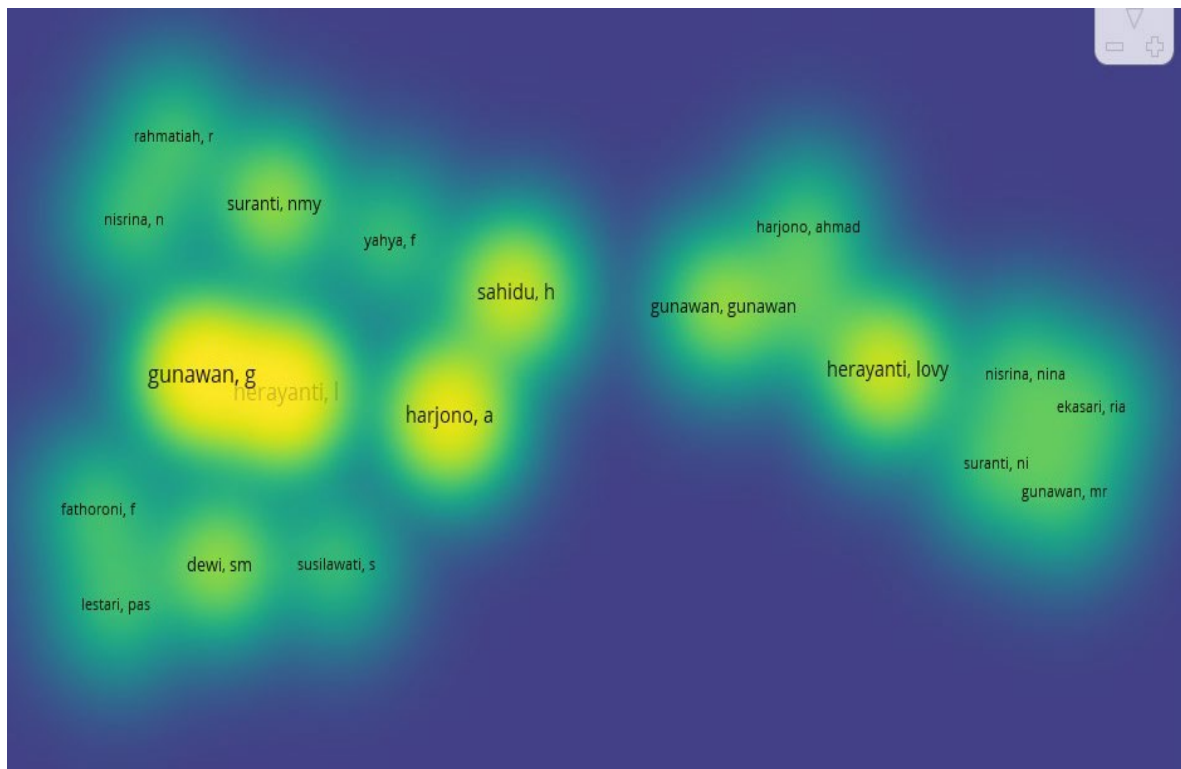


Figure 3 Authors connection density distribution by co-authorship Google Scholar

The literature database on virtual laboratory use in education is analysed in the VOSviewer program via the RIS file via the Google Scholar search engine. In this context, nearly a thousand data points were analysed and visualized. Figure 3 examines the connection between co-authorship and authors in relation to the usage of virtual laboratories in education through the Google Scholar search engine. As a result of the analysis, approximately 20 relevant links were identified. The obtained connections were examined in the density visualization pane. It is also seen in the density visualization distribution that the distribution is generally shaped by the co-authors, Gunawan and Heryanti.

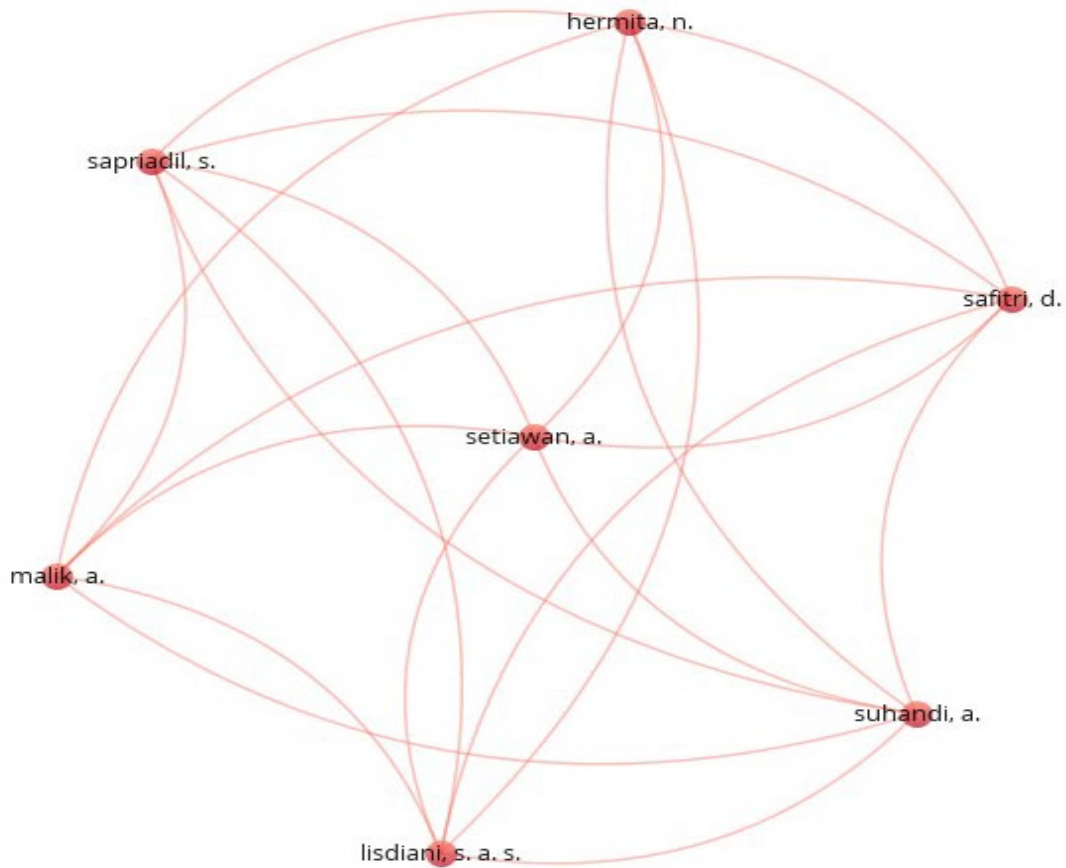


Figure 4 Authors connection with co-authorship Web of Science

The literature database on virtual laboratory use in education is analysed in the VOSviewer program via the BIBTeX file via the Web of Science search engine. In this context, nearly two thousand data points were analysed and visualized. Figure 4 examines the connection between co-authorship and authors. As a result of the analysis, approximately seven related links were identified. The obtained connections were examined in the network visualization pane.



Figure 5 Co-authorship and countries connection Web of Science

The literature on the use of virtual laboratories in education via the Web of Science search engine is examined in Figure 5. The connection between co-authorship and countries. As a result of the analysis, approximately 23 relevant links were identified. The obtained connections were examined in the network visualization pane. With conclusion of the examination, it came to the conclusion that there was no joint authorship between the countries.

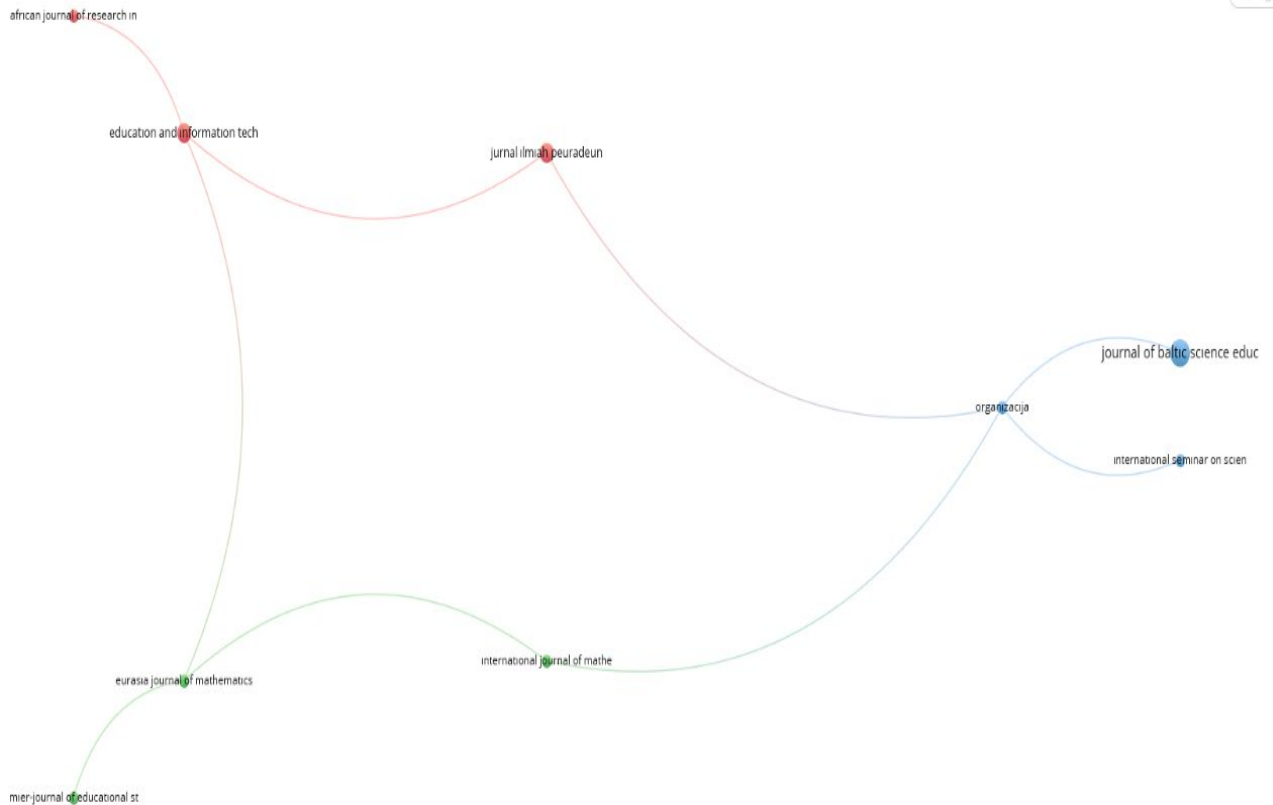


Figure 8 Citation and sources connection Web of Science

The literature on using virtual laboratories in education via the Web of Science search engine is examined in Figure 8. The connection between citations and sources. As a result of the analysis, approximately nine related links were identified. The obtained connections were examined in the network visualization pane. It can be seen that the relationship between citations and sources is divided into three main structures.

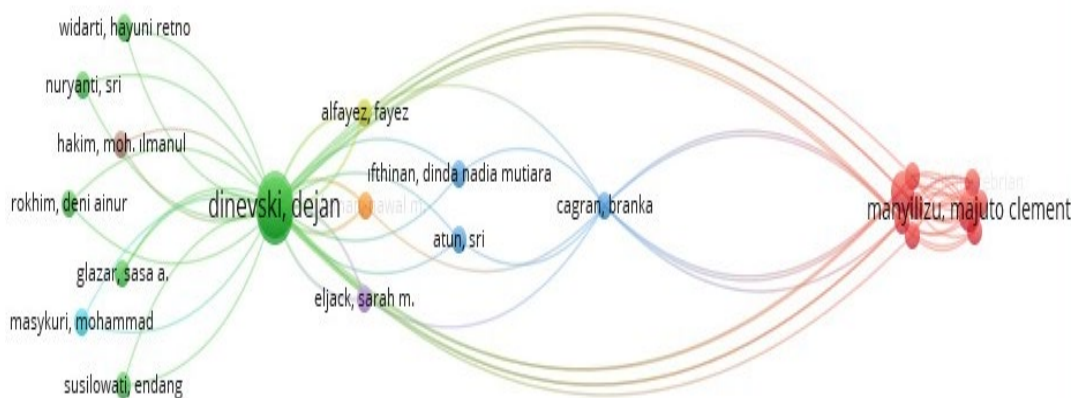


Figure 9 Citation and authors link Web of Science

The literature on the use of virtual laboratories in education via the Web of Science search engine is examined in Figure 9. The connection between the citation and the authors. As a result of the analysis, approximately 24 relevant links were identified. The obtained connections were

examined in the network visualization pane. It is seen that the distribution is generally shaped by the co-authors of Dinevski, Dejan, and Manyilizu, Majuto Clement.

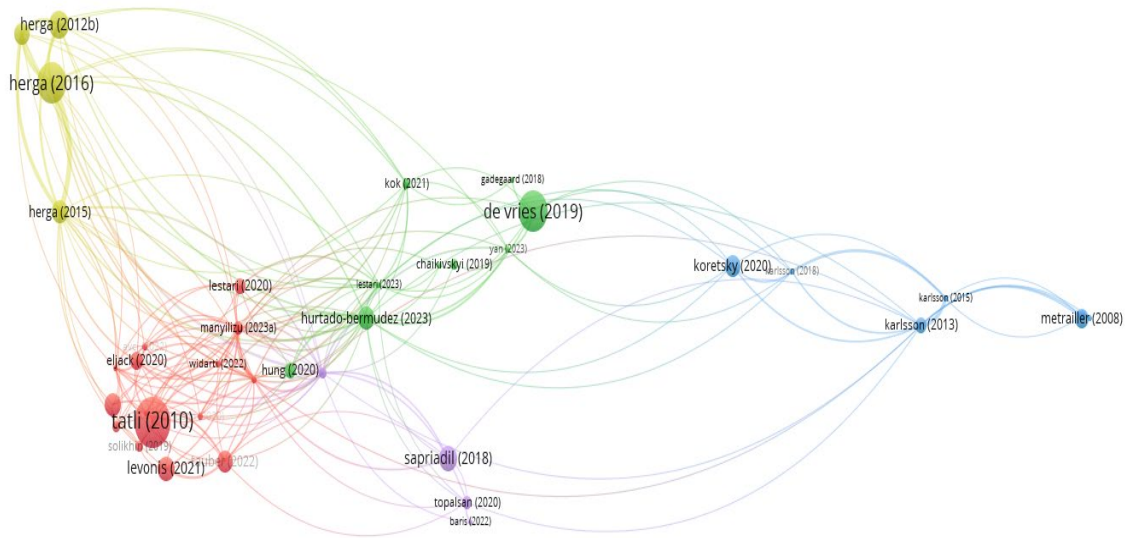


Figure 10 Documents connection with bibliographic coupling Web of Science

The connection between bibliographic coupling and documents is examined in the literature on the use of virtual laboratories in education through the Web of Science search engine in Figure 10. As a result of the analysis, approximately 39 relevant links were identified. The connections were examined from the network visualization pane. It can be seen that bibliographic links are divided into five main structures.

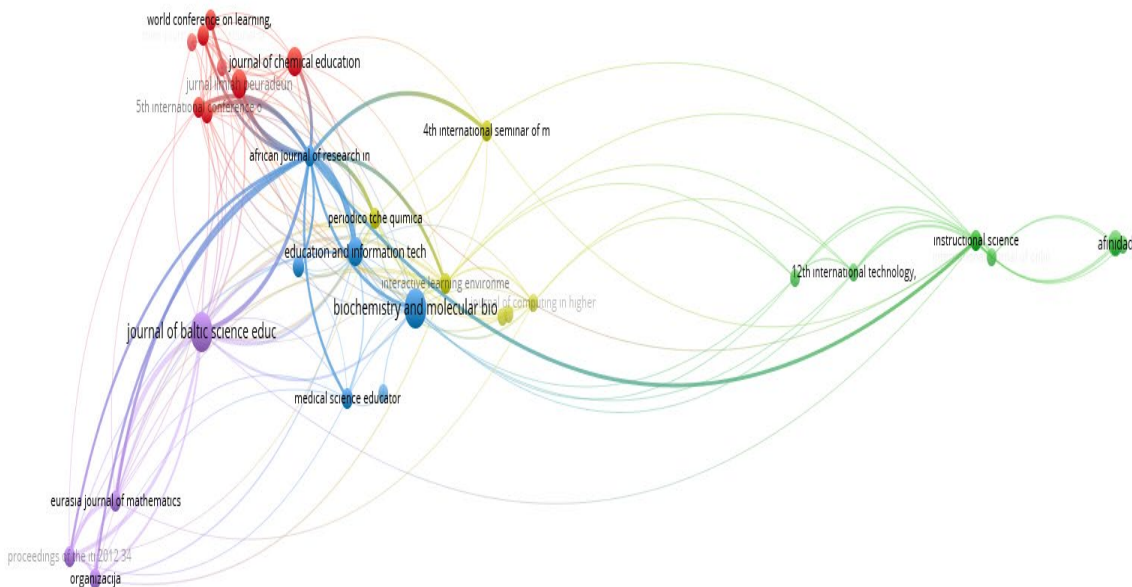


Figure 11 Sources connection with bibliographic coupling Web of Science

The literature on using virtual laboratories in education via the Web of Science search engine is examined in Figure 11. The connection between bibliographic coupling and sources. As a result of the analysis, approximately 31 relevant links were identified. Connections were examined from the network visualization pane. It can be seen that bibliographic links are divided into five main structures.

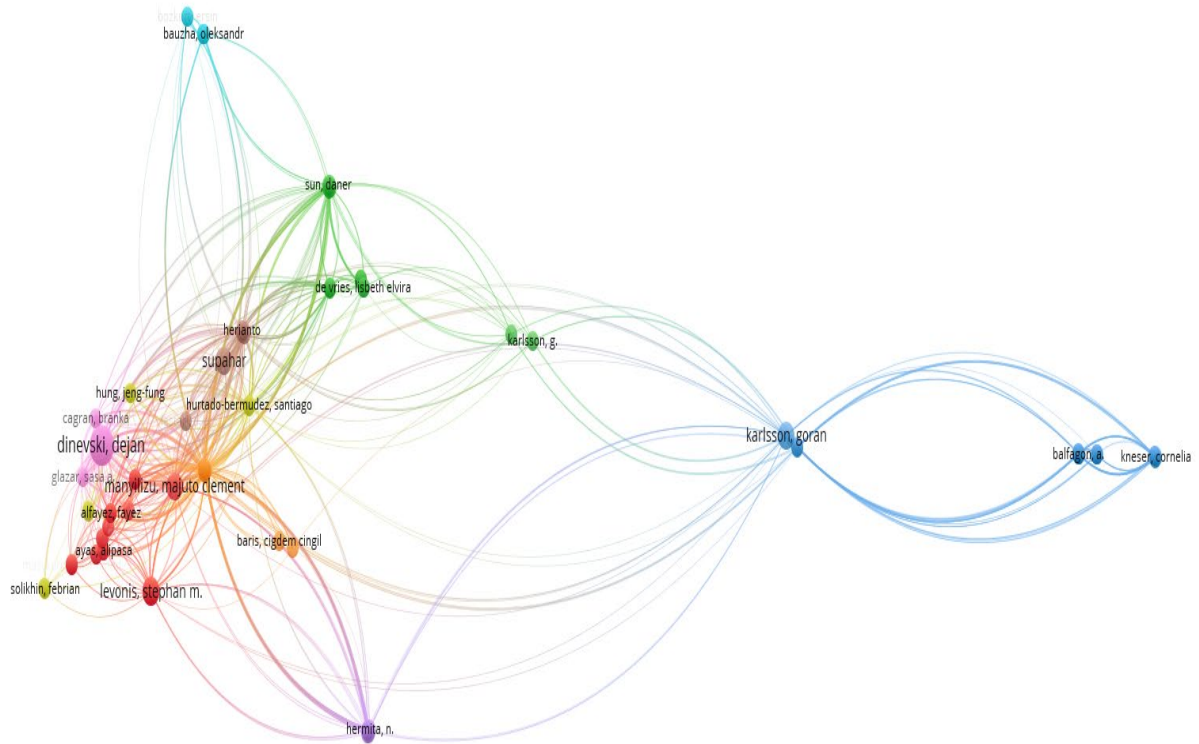


Figure 12 Authors connection with bibliographic coupling Web of Science

The literature on the use of virtual laboratories in education via the Web of Science search engine is examined in Figure 12. The connection between bibliographic coupling and authors. As a result of the analysis, approximately 91 relevant links were identified. Connections were examined from the network visualization pane. It can be seen that bibliographic links are divided into eight main structures.

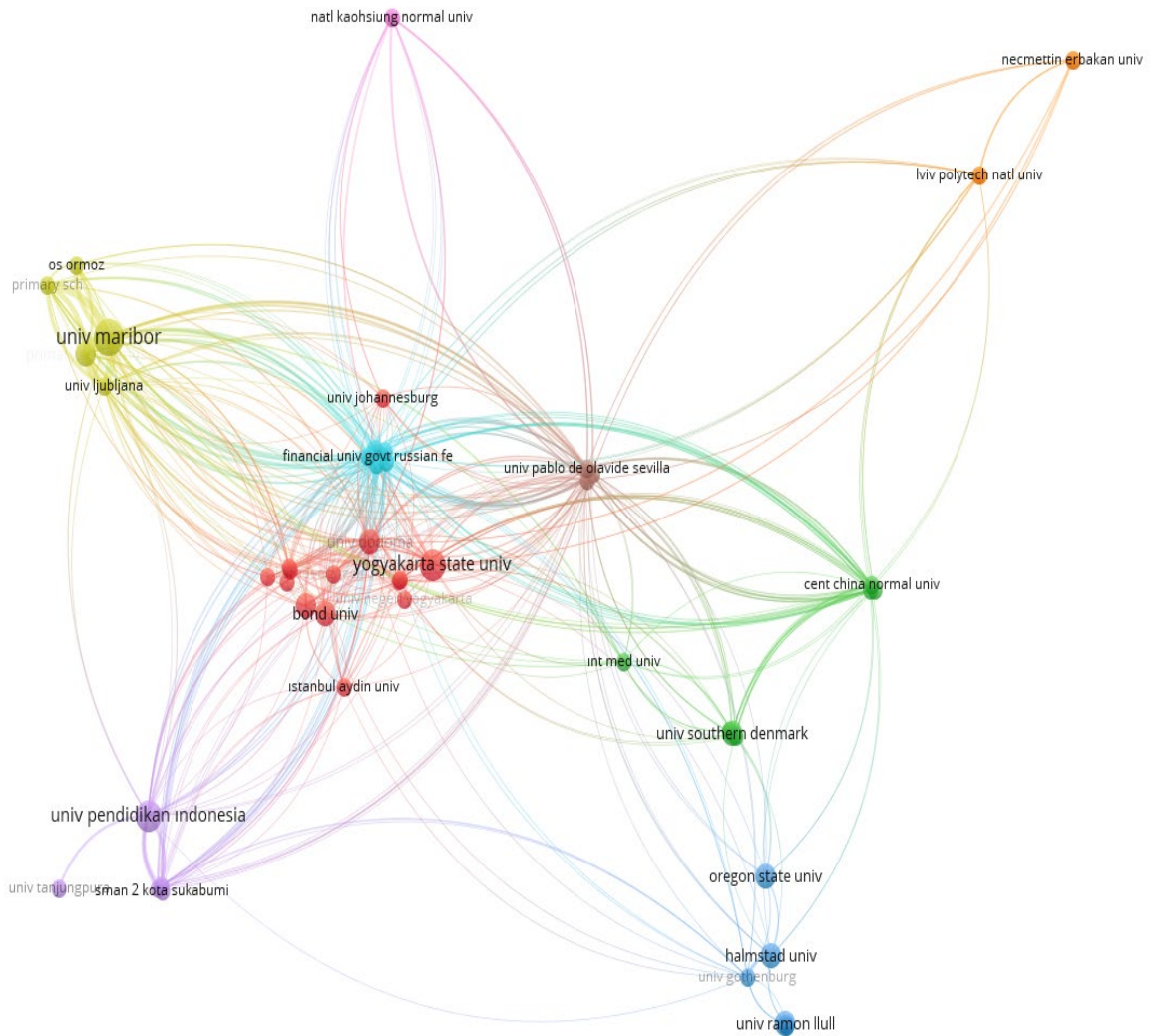


Figure 13 Linking organizations with bibliographic coupling Web of Science

The connection between bibliographic coupling and organizations is examined in Figure 13 of the literature on the use of virtual laboratories in education via the Web of Science search engine. As a result of the analysis, approximately 52 relevant links were identified. Connections were examined from the network visualization pane. It can be seen that bibliographic links are divided into nine main structures.

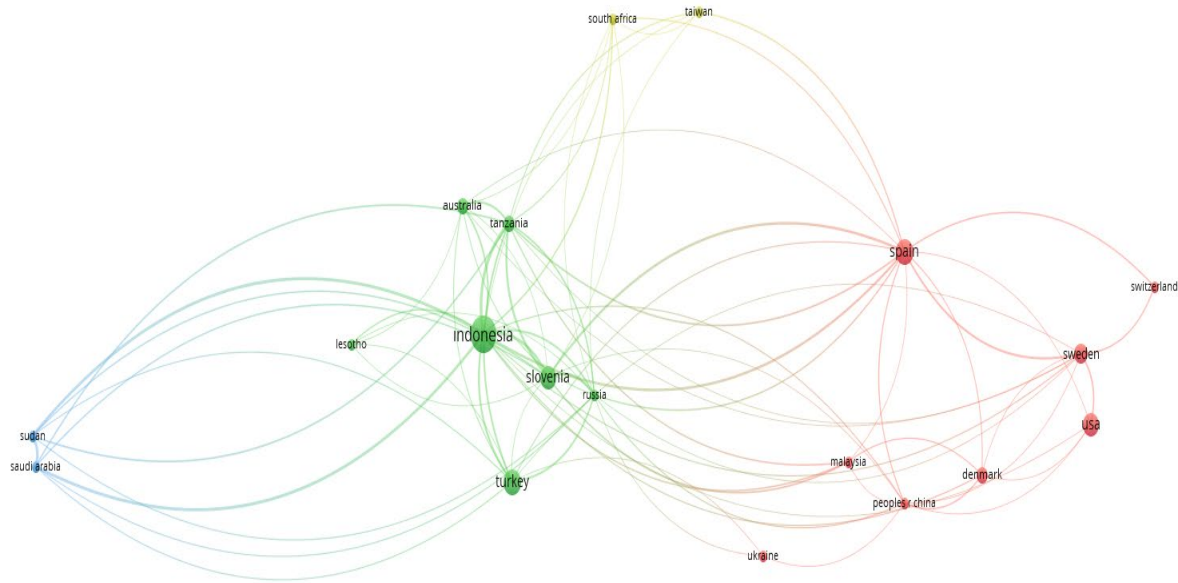


Figure 14 Linking countries with bibliographic coupling Web of Science

The literature on using virtual laboratories in education via the Web of Science search engine is examined in Figure 14. The connection between bibliographic coupling and countries. As a result of the analysis, approximately 19 relevant links were identified. Connections were examined from the network visualization pane.



Figure 15 Linking cited references with co-citation Web of Science

The literature on using virtual laboratories in education via the Web of Science search engine is examined in Figure 15. The connection between co-citation and cited references. As a result of the analysis, approximately 914 relevant links were identified. Connections were examined from the network visualization pane.

Result and discussion

In this study, the VOSviewer bibliometric mapping program, which is an open-access program that has been frequently used in international research in the last decade but has received less attention in national publications, is mentioned, and this study tries to explain the use of the VOSviewer program on the axis of virtual laboratory research in education, trying to gain depth from the bibliometric mapping approach.

The studies detailed in the flow diagram were obtained by scanning the phrase "Virtual Laboratory" in the title, abstract, and keywords of the database and restricting the scientific field and language of the studies. In this context, searches were carried out on the Google Scholar and Web of Science search engines. After the studies were purified from repetitive studies and studies outside the scope of the research through further screening, approximately two thousand studies were reached and downloaded and saved in file formats with various extensions such as CSV, RIS, and BibTeX. In line with the purpose of the research, the general view of virtual laboratory research using the VOSviewer program was mapped with bibliographic matching, co-citation, co-authorship, concept association, and citation network analysis techniques within the framework of the application. The results of the research show that the research with the highest citation network was carried out by Gunawan, Herga, Dinevski, Manyilizu, and Majuto Clement, and the basic concepts representing the studies in the field are VOSviewer, education in chemistry, molecular biology, and technology. It is intended that the research results will serve as a guide for future research.

Bibliometric analysis in use the field of education is an important tool that facilitates access to and evaluation of information for researchers, educators, and decision-makers. This method of analysis is used to measure the impact of educational research, identify trends, and predict future research directions. Consequently, the development of more effective and efficient educational policies and practices will be helped by the increased application of bibliometric analysis in the field of education.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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