Journal of Mathematics, Science, and Computer Education (JMSCEdu)
https://ppjp.ulm.ac.id/journals/index.php/jmsc-edu/index
Volume 2 Nomor 2 Tahun 2022

e-ISSN: 2807-9167
P-ISSN: 2807-9329

Model of Discovery learning in Science Learning: Bibliometric Analysis of the Current State of the art and Perspectives

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Received: 9 November 2022 **Accepted: 30 November 2022** **Published: 1 Desember 2022**

DOI: https://doi.org/10.20527/jmscedu.v2i2.6804

Abstract

This study aims to evaluate the most relevant themes related to discovery learning through bibliometric analysis, with its input using the keyword "Discovery learning in Science Learning". The Scopus index database is used in this study as the source database to conduct a bibliometric study for an academic article in the period between 1976 to 2022. This research also uses the VOSviewer app as a bibliometric analysis tool to visualize networks of authors, countries, journals, and keywords. This study found that the number of publications on discovery learning has grown periodically. This study also identifies the top ten authors, top ten affiliations, the top ten countries, and the top ten journal publications as sources in the field of discovery learning. Keyword analysis proves that the study of discovery learning in the last four decades has centred on themes related to computer science education, learning models, discovery learning, public understanding/outreach, high school/introductory chemistry, and constructivism. The bibliometric analysis presented in this study provides relevant information about the main theme learned about discovery learning in science learning, which is seen in the increase in creativity, learning outcomes, and student achievement in school teaching and learning activities.

Keywords: *Bibliometric Analysis*; *Discovery Learning; Science*

How to cite: Pratiwi, N. I., Misbah, M., Miriam, S., Harto, M., & Muhammad, N. (2022). Model of discovery learning in science learning: bibliometric analysis of the current state of the art and perspectives. *Journal of Mathematics, Science, and Computer Education (JMSCEdu)*, 2(2), 114-127.

INTRODUCTION

The educational challenge that must be faced in the 21st century is that students are required to be able to master various skills. In general, important skills in the 21st century have four pillars of life: learning to know, do, be, and live together (Wulandari, Fitri, & Syamsurizal, 2022). In addition, the 21st century requires human resources who have various abilities, one of which is the ability to think critically-creatively; students are expected to improve creative, critical thinking skills through high-level reasoning, namely logical thinking. This is relevant to the content of the 2013 Curriculum, which demands that learning must encourage students to find out and emphasize logical, systematic, and creative thinking (Kemendikbud, 2013). The current curriculum adheres to the view that the teacher does not directly transfer knowledge to his students. Still, students, as learning

objects, must have the ability to seek actively, process and be able to use their knowledge. The discovery learning model is seen as a promising learning method. This is due to the active involvement of learners with domains that will generate a structured knowledge base compared to traditional method learning. As is known, where learning is by traditional methods, knowledge is only transferred to students. The role of an educator is less and more active in cognitive learning and fosters high learning motivation (Dwijayanti et al., 2020).

Discovery is a learning method developed based on constructivism. Discovery learning is also defined as a learning process that occurs when materials are not presented in their final form but are expected to organize themselves. Discovery learning is a method of developing active learning methods by finding oneself and investigating oneself. Then the results obtained will be faithful and long-lasting in memory. Discovery learning is also seen as a promising learning method because of the active involvement of learners with domains that will generate a structured knowledge base compared to traditional learning methods, where knowledge is only transferred to students. The role of educators is less and more active in cognitive learning and fosters high learning motivation (Wulandari et al., 2022).

A search was carried out in this bibliometric study to provide guidance on knowledge related to discovery learning. The goal is to assess the publication's sources, countries, authors, and the most cited themes about discovery learning. The study provides important information about emerging trends in research involving discovery learning. It also identifies hotspots that may be of interest as research areas. The systematics of this paper is structured as follows: in Part 2 we present the methodology applied to retrieving documents in a Scopus database and generating a bibliometric network. Part 3 presents the results and discussion of data retrieved from the Scopus database. In addition, Part 4 reviews the literature on the current state of the art and key perspectives for research involving Discovery learning based on keyword analysis. Here is a formulation of the problem in this study: (1) What is the number of discovery learning publications each year? (2) Who are the top ten authors in discovery learning? (3) Who are the top ten affiliates in discovery learning? (4) Who are the top ten countries that produce many articles in the field of discovery learning? (5) Who are the top ten sources that publish a lot on discovery learning? and (6) What are the main publications and research interests based on the author's keywords in the co-occurrence analysis? While the objectives of this study are (1) to describe the number of discovery learning publications each year, (2) to describe the top ten authors in the field of discovery learning, (3) to describe the top ten affiliates in the field of discovery learning, (4) describe the top ten countries that produce many articles in the field of discovery learning, (5) describe the top ten sources that publish a lot of discovery learning themes?, and (6) describe publications main and interest-based research on the author's keywords in the co-occurrence analysis.

METHOD

At the identification stage, a search based on the Scopus database using the keyword "Discovery learning, obtained 56 documents. The author does not filter the type of document, so the documents obtained are Article (37), Conference Paper (15), and Conference Review (4). Documents are exported to VOSviewer software for bibliometric analysis of publications, authors, countries, institutions, journals, and areas. Furthermore, data analysis is needed to identify the main themes discussed in the research developed on Discovery learning. Figure 1 shows the stages of the methodology and its main steps, as well as the analytical benchmarks applied to this study.

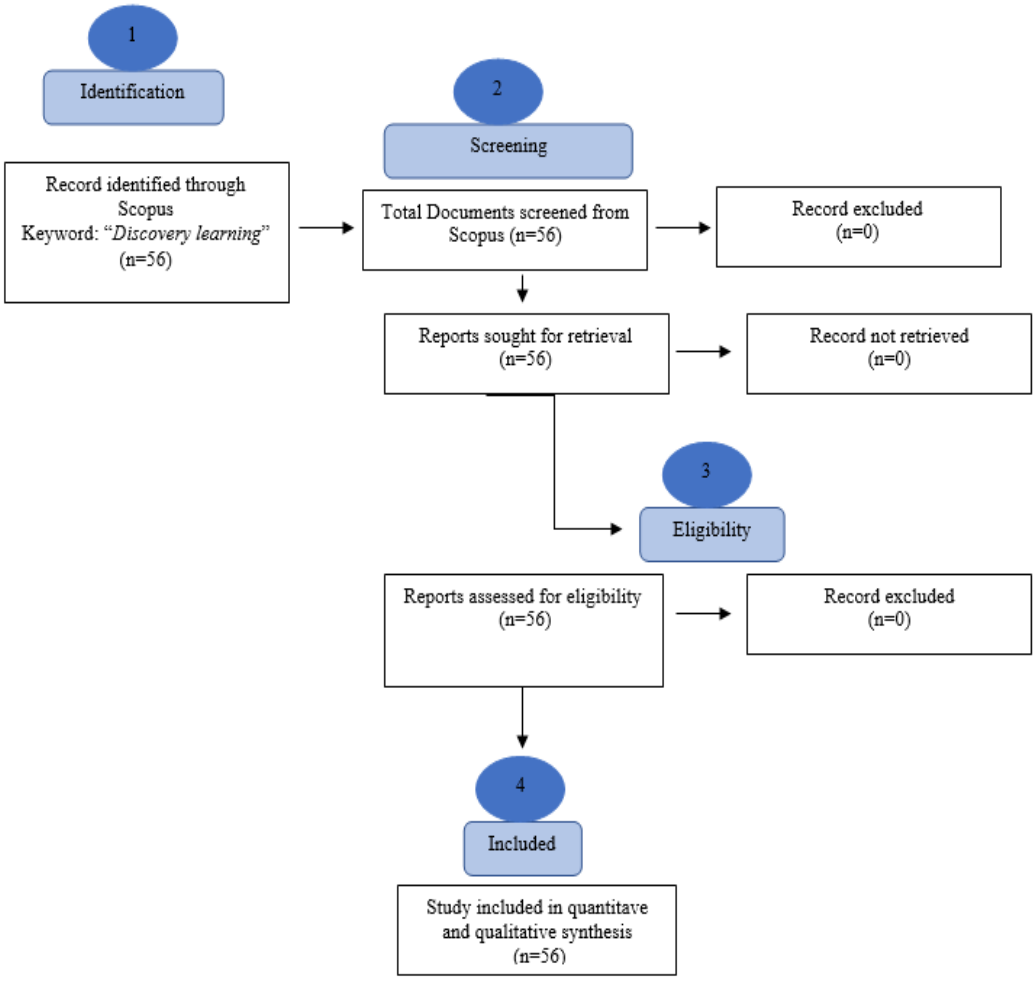


Figure 1 The Methodology Phase, Its Main Steps, and The Analytical Criteria Applied to This Study

This study used bibliometric analysis. An analysis conducted on July 13, 2022, found a total of 56 documents in the period from 1976 to 2022. The VOSviewer app is established as a bibliometric analysis tool for visualizing networks of authors, countries, journals, and keywords in this bibliometric analysis process. This data is used for co-authorship and co-occurrence analysis. Thus, it can give birth to a network map of authors, countries, and keywords. In addition, a network map of scientific journals is generated from the analysis of citations. The VOSviewer application (version 1.6.18, Leiden University, Leiden, The Netherlands) is used to construct and visualize bibliometric networks. This application is expected to extract information from publications, such as authorship, magazines, organizations, countries, and keywords.

RESULT AND DISCUSSION

Number of Discovery Learning Publications

Based on the keyword discovery learning in searches in the dataset of the last 46 years, the results of the number of documents published are as shown in Figure 2.

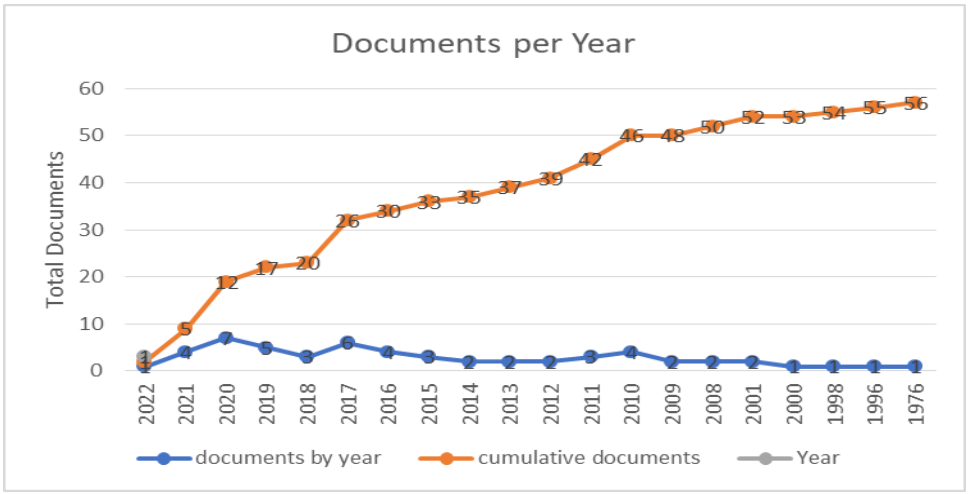
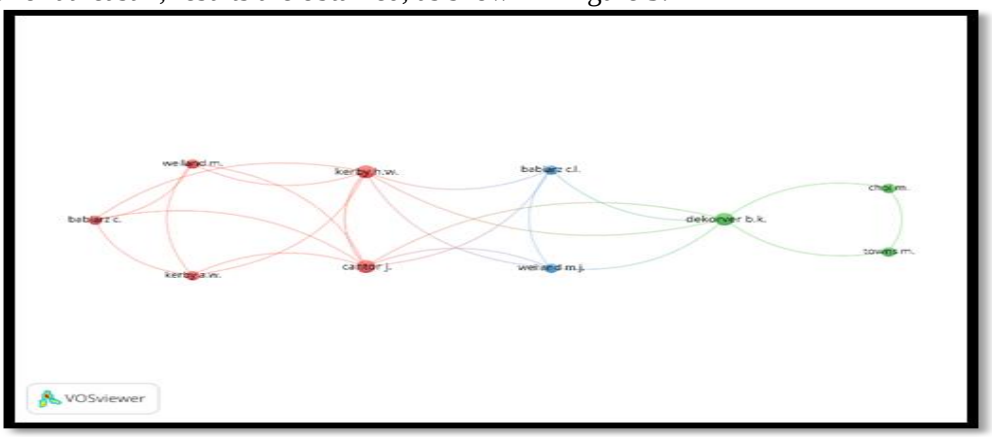


Figure 2 Documents per *Year* About *Discovery Learning*

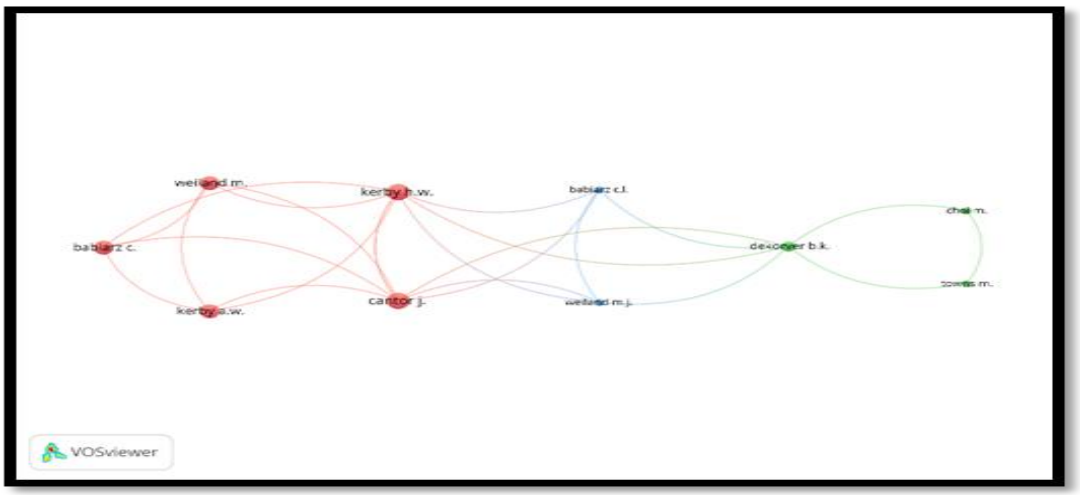
Figure 2 documents per year Discovery learning shows that based on the last 46 years of search in the Scopus database, 56 documents consisting of 37 articles, 15 conference papers and four conference reviews on discovery learning in the 1976-2022 period were obtained. Based on the number of documents published, shows that the trend has increased periodically every year. Based on the number of cumulative documents in each year, it has also increased in the last 46 years. So that it can be ascertained both from the cumulative number of documents and from the number of documents issued each year shows an increasing trend in the period under investigation (Figure 2).

Although the 2022 data shows a decrease from the previous years, it is not a sure thing to experience a decline because it is still in the update period. Researchers predict that in 2022 the number of published documents will increase, with the hope that after the update period, the number of publications in 2022 will exceed the figures in the 2022 data.

In fact, in the last 45 years, the number of publications has experienced an average annual growth of 3. This shows that research on Discovery learning is increasing every year. To find out the authors who are in discovery learning both in terms of the number of documents and their ideals, a Co-authorship analysis is carried out with unit analysis authors and counting method full counting and a maximum number of authors per document 25. Using the criteria for the minimum number of documents and the author's ideal of at least 1, results are obtained, as shown in Figure 3.



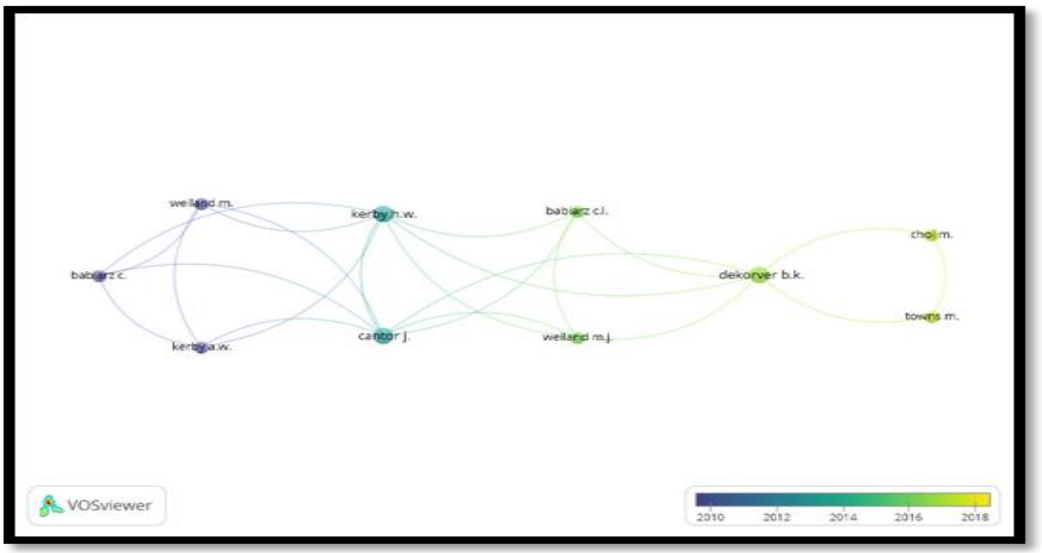
(a)



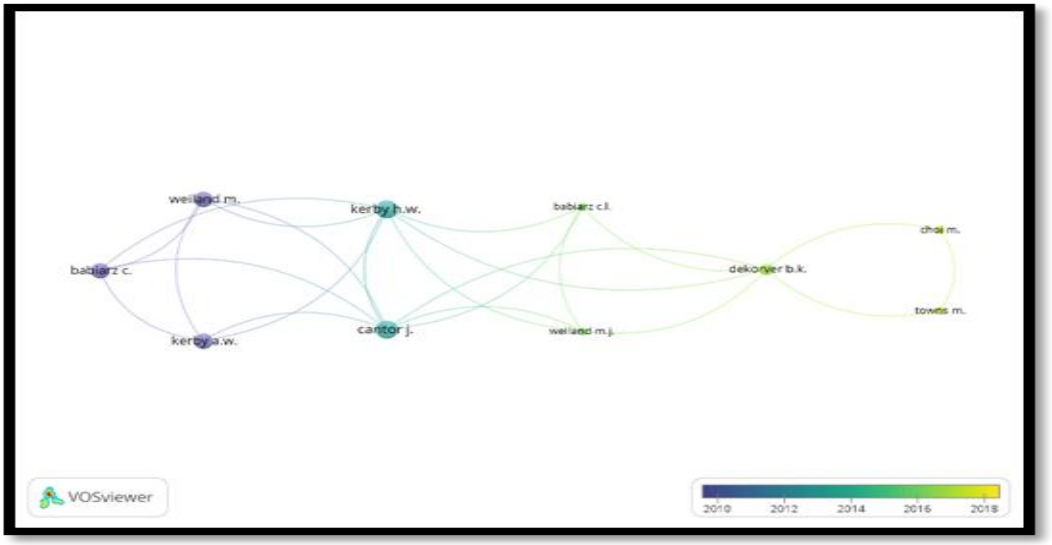
(b)

Figure 3 *(a) Network Visualization with Weights: Documents and (b) Network Visualization with Weights: Citations*

Figure 3 shows a map of authors from one another about authors collaborating on the topic of discovery learning. The size of the nodes in Figure 3(a) corresponds to the number of articles to which each author has contributed significantly, and in Figure 3(b) corresponds to the number of articles to which each author has contributed significantly. In Figure 3 (a), there are 3 clusters, where one of the clusters with authors Kerby H.W. and Cantor J. is connected to the other 2 clusters. For example, Kerby H.W. and Cantor J. are connected with DeKorver B.K., Babiarz C.L. and Weiland M.J. in research on demonstration show that promotes and assesses conceptual understanding using the structure of drama (Kerby et al., 2016) and others. Figure 3(b) also obtained 3 clusters where it is seen that Kerby H.W. and Cantor J. are also connected to 2 other clusters. In this study, the authors also displayed overlay visualization in Figure 4.



(a)



(b)

Figure 4(a) Overlay Visualization with Weights: Documents and (B) Overlay Visualization with Weights: Citations

Figures 4 (a) and (b), only a few authors have researched discovery learning in 2018. One is research from Dekorver b.k., Choi m., and Towns m. Who researched the Exploration of a Method To Assess Children's Understanding of a Phenomenon after Viewing a Demonstration Show (DeKorver et al., 2017).

Top authors in the field of Discovery Learning

The graph below reveals many documents and citations of the ten most influential authors in discovery learning (Figure 5).

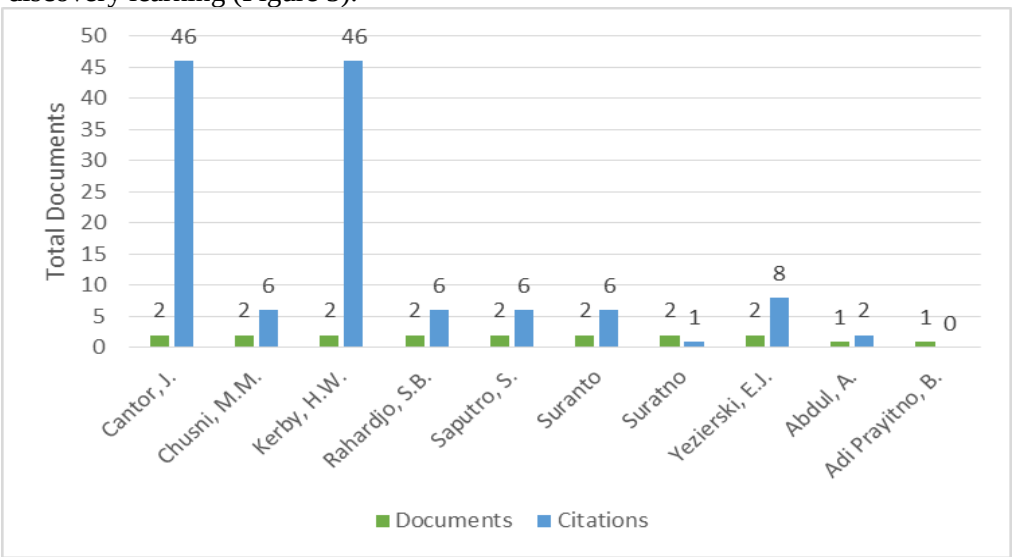


Figure 5 10 Influential Authors Based on The Total Number of Relationships Between Documents and Citations

Figure 5 shows a diagram of the top 10 authors based on the total number of relationships between documents and citations. In the diagram, there is a balance between the number of documents and the number of citations obtained by Cantor J. and Kerby

H.W. of the University of Wisconsin-Madison, Madison, United States, whose study is entitled Fusion science theatre presents the amazing chemical circus: A new model of outreach that uses theatre to engage children in learning (Kerby et al., 2010). Followed by Yezierski, E.J., who has the second highest number of citations from Miami University, Oxford, United States, in his research entitled applying the next generation science standards to current chemistry classrooms: How lessons measure up and how to respond and combining novel visualizations and synthesis to explore structure-property relationships using cobalt complexes (Kellamis et al., 2019). Then there is also a balance in the authors Chusni, M.M., Saputro, S., Suranto, and Rahardjo, S.B. from Sebelas Maret University, Central Java, Indonesia, whose research discusses the conceptual framework of designing a discovery learning modification model to empower students' essential thinking skills and the potential of discovery learning models to empower students' critical thinking skills (Chusni et al., 2020). Based on the explanation of the diagram, it can also be known that the three authors with the first and second most citations come from the United States, and the third most cities come from Indonesia.

Top Affiliates in the Field Discovery Learning

Figure 6 shows ten productive affiliations in the field of discovery learning.

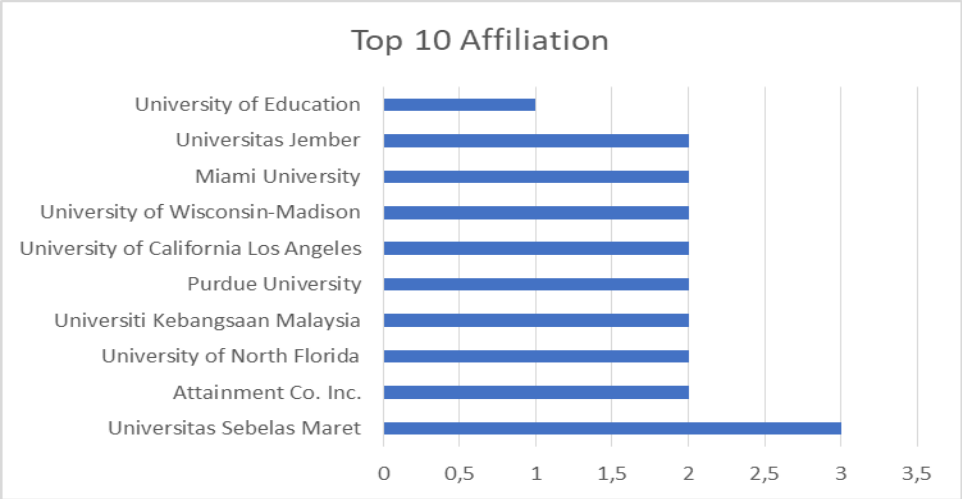


Figure 6 Ten Productive Affiliations in The Field of Discovery Learning

Figure 6 Explains that most of the articles were published by Sebelas Maret University, which is as many as three articles. A total of 2 articles from the University of Jember published each, Miami University, University of Wisconsin-Madison, University of California Los Angeles, Purdue University, Universiti Kebangsaan Malaysia, University of North Florida, and Attainment Co. Inc. Then followed by the University of Education which published 1 article. In Figure 6, it is concluded that the affiliation is mostly in the United States and conformity with the explanation in Figure 5, which states that most authors are from the United States. This is also closely related to Figure 7, which shows ten productive countries in discovery learning.

Countries That Produce Many Articles in the Field Discovery Learning
Figure 7 shows ten countries productive in the field of discovery learning.

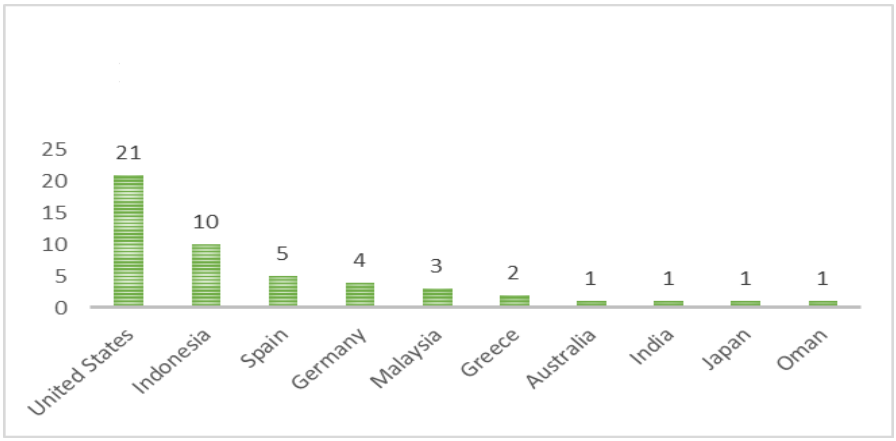


Figure 7 10 Productive Countries in The Field of Discovery Learning

Figure 7 it can be seen that the United States is the most productive country in publishing documents on discovery learning, namely 21 documents. Then it can be seen that Indonesia managed to rank second most in publishing documents about discovery learning, namely as many as ten documents. Furthermore, in the third order, there is Spain with many document publications, as many as five documents, Germany with four documents, Malaysia with two documents, and Australia, India, Japan, and Oman, each of which has 1 document. Figure 7 shows that Indonesia has the most document publications, namely ten documents, followed by Malaysia 3 documents and Oman 1 document.

Top Sources for Discovery Learning

The following are ten sources from journals and proceedings that publish many articles on discovery learning (Figure 8).

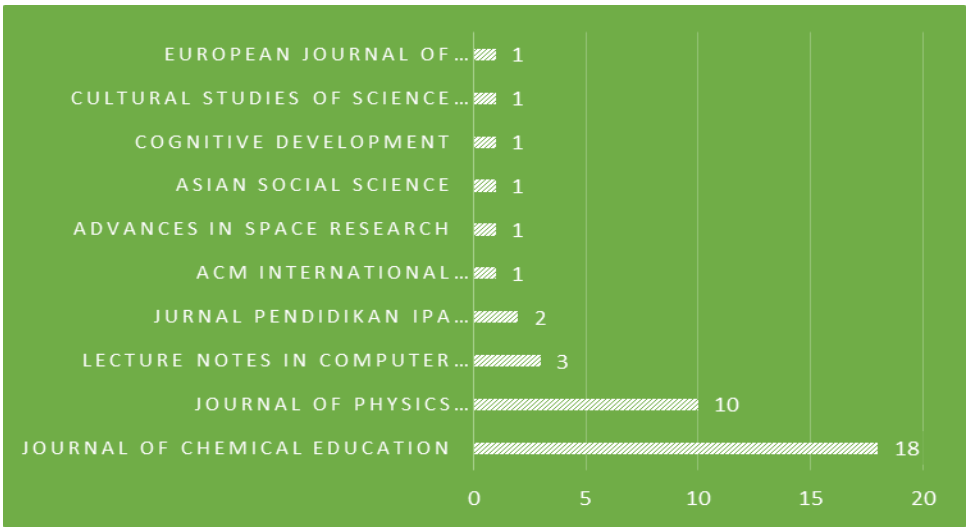


Figure 8 10 Journals/Proceedings that Publish a Lot of Discovery Learning Articles

Figure 8 Explains that the journal largely domiciles the source of the article. A total of 18 articles from the Journal of Chemical Education occupy the first position, and ten articles from the Journal of Physics Conference Series occupy the second most articles published in discovery learning.

Key Publications and Research Interests Based on Keywords

The result of primary publications and research interests based on the author keyword in co-occurrence analysis is shown in figure 8. Based on a search through co-occurrence analysis with the minimum criteria of occurrence of a keyword=2, then from 266 keywords, 40 meet the threshold were obtained.

The discovery learning keywords obtained in Figure 9 are classified into five clusters. Of course, the most highlighted keyword is in cluster 1 and throughout the network, namely "Discovery learning". The main keywords represented in cluster 1 tend to focus on the education system of Discovery learning, such as collaborative discovery learning, computer science education, computer-aided instruction, and science education (Cluster 1 is marked in red).

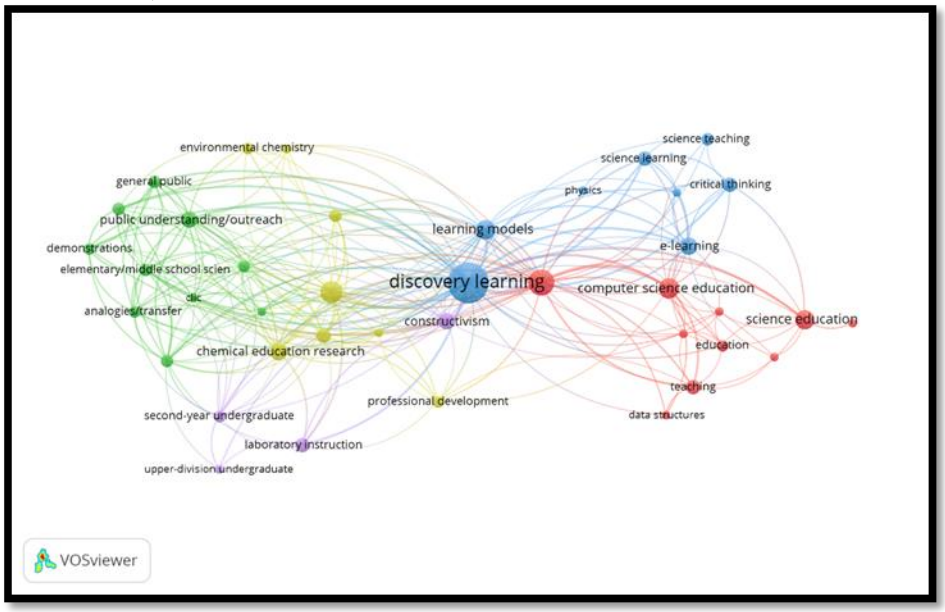


Figure 9 *NetworkVisualization Discovery learning* based on *Co-occurrence Analysis*

In addition, the focus also includes implementing discovery learning, such as teaching and experiments. Discovery learning is a modern learning model that emphasizes the direct experience of learners to find their knowledge as a pure form in the educational process. Therefore, learners will do many experiments. Discovery learning concerning computational experimentation using a computational experimentation approach through electronic worksheets. This approach is based on the principles of discovery learning extended with the principles of constructivist, socio-cultural and adult learning theory, the concept of computer-based cognitive tools and the aspects on which computational experiments are based. Sofyan, Wasis, and Ibrahim 2017 revealed their findings, namely that discovery learning can increase students' creativity in edutainment-based physics learning (Winarti et al., 2021). In other relevant research, discovery learning can improve student learning outcomes in physics learning in circular motion materials (Mardiana et al., 2021). Using interactive digital teaching materials in science learning using the discovery learning model can increase student learning achievement (Khamidah et al., 2019).

In cluster 2, the main keyword is public understanding/outreach. The main words in this green cluster are related to the application of discovery learning, such as analogies/transfers, demonstrations, elementary/middle school, graduate education/research, and first-year undergraduate/general. Demonstration performances

are a popular chemistry education outreach to increase chemical interest, engagement, and appreciation. Although practitioners often include instructional elements, evaluation is limited to children's attitudes towards science rather than their understanding of the basic concepts presented. In addition, words such as interdisciplinary/multidisciplinary and misconceptions/discrepant events appear in this cluster.

In cluster 3, the prominent keyword is discovery learning. The main words in this cluster in blue are related to the discovery learning system, such as e-learning, learning models, and literature reviews. In addition, in this cluster also appear words such as critical thinking and science learning. Critical thinking is the ability to think logically, apply this rational thinking to evaluate problems and make good judgments and decisions. Applying the discovery learning model to science learning is hoped to spur students' critical thinking further.

In cluster 4, the prominent keyword is a high school/introductory chemistry. The main words in this yellow cluster are related to science's process (relationship) with discovery learning, such as chemical education research, environmental chemistry, problem-solving/decision-making, and professional development. In addition, in this cluster also appear words such as curriculum, which is part of the application in discovery learning. Through discovery learning, it is hoped that students will be able to develop science learning through the environment and then make decisions to solve problems that arise during the development process in science learning based on the established curriculum.

In cluster 5, the main keyword is constructivism, a theory that prioritizes the development activities of something that has been studied. The main words in this purple cluster are related to the application of discovery learning, such as laboratory instruction, second-year undergraduate, and upper-division undergraduate.

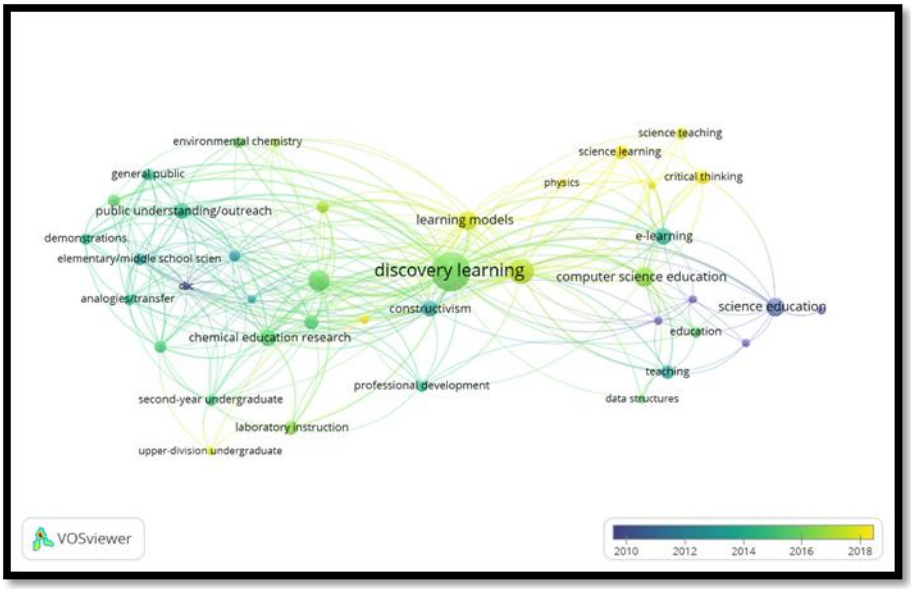


Figure 10 Overlay Visualization Discovery learning based on Co-occurrence analysis

Figure 10 shows that discovery learning in the last four years tends to discuss science learning, critical thinking, and physics. This is an opportunity for researchers to conduct further research. The discovery learning model has the potential to empower critical thinking skills starting from the hypothesis generation stage which aims to provide rational argumentation from the stage of orientation of real phenomena followed by the process of interpretation, analysis, evaluation, inference of the results of the hypothesis

experiment of the testing stage until the right conclusion is obtained from the results of the experiment.

CONCLUSION

In the last four decades (1976-2022), the number of publications on Discovery learning has grown periodically. Cantor J., Kerby H.W., Yezierski, E.J., Chusni, M.M., Saputro, S., Suranto, Rahardjo, S.B., Suratno, Abdul, A., dan Adi Prayitno, B. is the top ten author in the field of discovery learning. Then the top ten affiliations in the field of discovery learning are Universitas Sebelas Maret, Universitas Jember, Miami *University*, *University* of Winconsin-Madison, *University* of California Los Angeles, Purdue *University*, Universiti Kebangsaan Malaysia, *University* of North Florida, Attainment Co. Inc., and *the University* of Education. The United States and Indonesia top the list of 8 other countries, such as Spain, Germany, Malaysia, Greece, Australia, India, Japan, and Oman. The top ten sources in this field are Journal Of Chemical Education, Journal Of Physics Conference Series, Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics, Jurnal Pendidikan IPA Indonesia, ACM International Conference Proceeding Series, Advances In Space Research, Asian Social Science, Cognitive Development, Cultural Studies Of Science Education, dan European Journal Of Educational Research. Keyword analysis proves that the study of discovery learning in the last four decades has centred on computer science education, learning models, discovery learning, public understanding/outreach, high school/introductory chemistry, and constructivism.

The bibliometric analysis presented provides relevant information about the main theme learned about discovery learning in science learning, which is seen in the increase in creativity, learning outcomes, and student achievement in school teaching and learning activities.

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