Bibliometric Analysis of *Blended learning* Mathematics in Scientific Publications Indexed by Scopus

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Article Info	Abstract
	Research of blended learning in mathematics using the bibliometric method is still relatively rare. Therefore the novelty of this research is through the method used bibliometric analysis, data sources from Scopus database with restrictions on articles published in 2011 until 2021 analyzed with Publish or Perished (PoP) application and visualization using Vosviewer. The sample of this research is scientific articles about blended learning mathematics indexed by Scopus published in the last ten years, from 2011 to 2021, as many as 136 scientific articles. The research method used is a bibliometric analysis conducted on 136 publications on blended learning mathematics learning on the Scopus database. Data analysis carried out is citation analysis, publication trend analysis, trend analysis, and analysis of author keywords. Research articles on blended learning mathematics learning published in Scopus indexed journals have generally experienced positive growth from year to year. The most citations to articles related to blended learning occurred in 2019 with 107 article citations., the articles that were used the most as references in these writings had a good impact on the creation of knowledge related to blended learning mathematics and research opportunities. Keywords that are rarely used related to blended learning in mathematics learning are analysis and Schoology. These two keywords can be a reference for further research in the future. It indicates that the opportunity to research this topic is still extensive.

INTRODUCTION

History has proven that the development of world revolutions influences the transformation of education in a country. The education system in the world today is demanded to be more dynamic and flexible, namely by implementing a 4.0-based education system. According to Aoun, the 4.0 education system consists of three new literacy, namely: 1) data literacy: the ability to understand and utilize big data, 2) technological literacy: knowledge of mathematics, coding, and basic engineering principles, and 3) human literacy: the ability to socialize. Communicate, engage with others, and harness our human capacities for elegance and beauty [1]. If the learning process is carried out using technology to be done anywhere and anytime, this is the main characteristic of education 4.0.

As we all know, human civilization has changed a lot in the last ten years and is influenced by technological developments. Humans in meeting their needs have been helped by everything that is a product of technology, in education, where the internet is one of the technological products that can support the learning process in the classroom. In line with the opinion expressed by Bakhouyi et al.; that the internet is not only used as a time and space breaker in learning, it can also be used by a teacher to help complete the references needed in learning [2]. It indicates a shift in

learning patterns from initially in the classroom to any place anywhere and anytime, initially from classrooms to virtual spaces, from physical media to online media.

Technological developments significantly influence education, one of which is in the learning process [3]. Various innovations in education can be seen from the emergence of the application of technology as an innovation in education—the learning process where internet-assisted as supporting learning is known as e-learning [4]. Meanwhile, according to Rakic, e-learning is defined as a learning process assisted by electronic devices [5]. In general, Juan et al. stated that e-learning is learning carried out using digital technology [6]. At the same time, some other researchers define e-learning as any learning supported by the internet or web-based.

The Covid-19 pandemic impacted home learning policies in early 2020 and forced educators to use various technologies such as Learning Management Systems (LMS) and video conferencing in the learning process. Implementation of the policy requires teachers and students learning activities to teach it online at home. Thus, students do not stop getting an education and help the government break the chain of transmission of Covid-19. The use of e-learning in the current situation is alternative learning that is expected to support the teaching and learning process optimally [7].

The e-learning learning model is the choice of educators because it accommodates learning needs without being bound by place, anticipates student assignments, and assesses them [8]. One of the efforts to apply to learn is divided into two parts, face-to-face and experience in blended learning [9]. The combination of an electronic learning environment and traditional learning is a blended learning concept. In practice, blended learning combines asynchronous and synchronous learning and face-to-face [10], consisting of 3 components: online, face-to-face, and independent learning [11].

The basic concept of blended learning combines online learning (through internet facilities/media with face-to-face learning (meeting face to face /classical). According to experts, the percentage between face-to-face or online in blended learning according to experts there are differences of opinion, some state 30% online 80% face-to-face and there are also 40%-70%. Several research results obtained results that state the advantages of blended learning can optimize the abilities and capabilities of students and are considered suitable to be applied in the current pandemic conditions where learning activities take place online so that they can collaborate with face-to-face online methods especially in learning mathematics.

The use of blended learning in mathematics learning has been researched and claimed to have a good impact because it can increase the accessibility and independence of students' learning before, during, and after the learning process. Blended learning allows students to learn the material before the learning process begins without time and distance constraints to encourage their independence. Students can be involved effectively and efficiently to develop creativity, discussion, and problem-solving during the learning process. The main finding of research that the application of blended learning demonstrated the effectiveness of that both in the learning of mathematics, it is because the use of LMS enables students and teachers in the process of learning [12], [13]. After all, it can be accessed anytime and anywhere without limited space and time. The application of Schoology-assisted Blended learning can increase student activity and achievement [14]. Furthermore, motivation and learning achievement for the experimental class that uses the blended learning model is higher than the control class students who use the conventional model. In other

words, the blended learning model has a positive effect on motivation: achievement and student learning achievement in mathematics [15].

Big data related to blended learning research in mathematics learning has been done quite a lot. Therefore, we need to process the data for various purposes, such as determining further research, which is still rarely done. Bibliometric studies are one way to collect, process, and analyze metadata of research articles from various databases such as Google Scholar, Scopus, and Web of Science. As we know, the databases in Google Scholar and Scopus provide information regarding the structure of articles in general. Through bibliometric studies, we can understand the hierarchy of science, research development on a particular theme [16], the gaps in research, and the number of references from one article to another qualitatively and quantitatively [17].

Bibliometric research related to blended learning in mathematics learning is claimed to be rarely done. Therefore, this study was conducted to find trends in the development of articles about e-learning in mathematics learning using the Scopus database from 2011 to 2021. The analysis carried out included citation analysis, authors, theme classification, theme clustering, author network, research depth, and research area that is still rarely done [18]. The purpose of this study is to analyze how the development trend of blended learning mathematics research publications published in Scopus indexed scientific journals, review citation analysis, and examine trend analysis of keyword terms by the author.

METHOD

The population in this research is articles about blended learning in mathematics learning using the Scopus database as many as 143 publications on June 10, 2021. From 143 articles, 136 research samples were obtained from 2011 to 2021. Bibliometric analysis methods were used to collect, process and analyze data related to blended learning in mathematics learning. Data collection using Publish or Perish (PoP) and data visualization using VOSviewer.
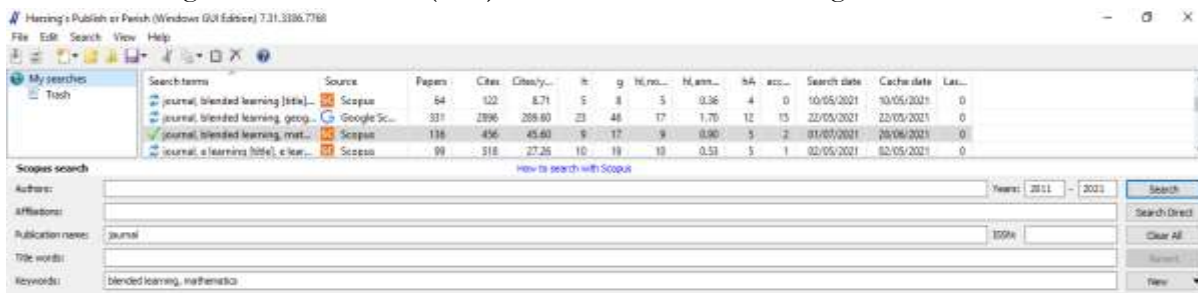

Figure 1. Scopus Database Database Search

Figure 1 shows the first step in collecting the Scopus database related to blended learning in mathematics with the keywords "Blended Learning" and "Mathematics". The data used is already available in the Scopus database. The ways to obtain data are: first, accessing www.scopus.com; second, limiting the search menu, by entering the keyword "blended learning", selecting the "data range" for publishing articles by writing the numbers "2011" to "2021", third, determining the type of document by clicking on "journal"; fourth, obtain data from the Scopus database by clicking "search"; Fifth, save the search result data into RIS format with the aim that it can be processed using Microsoft Excel and VOSviewer.

Figure 2. Data Storage in RIS Format

Furthermore, the data collection results are stored in RIS format, as shown in Figure 2 for cleaning. In this study, the data analysis techniques used were descriptive quantitative and descriptive qualitative. The data processed in scientific publication journals about blended learning mathematics learning by year, author, title, and subject were analyzed using Microsoft Excel 2010. Meanwhile, Vosviewer software was used to analyze the development map of blended learning mathematics learning scientific publications. The output form of data processing with excel is in the form of a graph, for the output of VOSviewer is a network map based on keywords and based on the author. The next stage is to enter Vosviewer to visualize the analysis results, as shown in Figure 3.
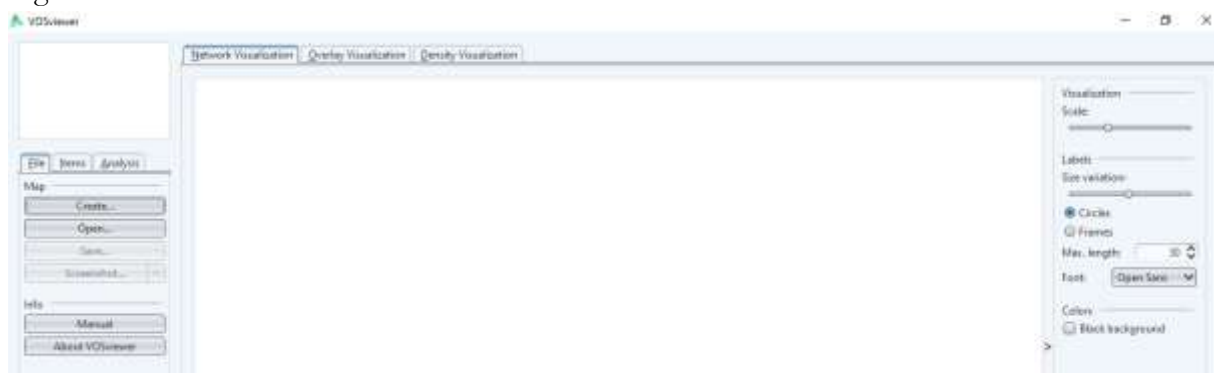

Figure 3. Data Visualization in VOSviewer

RESULTS AND DISCUSSION

The data collection and analysis results related to blended learning in mathematics learning can be seen in table 1. From table 1 above, we can obtain information that the highest number of publications of articles on blended learning mathematics learning occurred in 2020 (30.37%). Mathematics learning blended learning research articles published in Scopus indexed journals have generally experienced positive growth. Table 1 illustrates that research has increased from year to year, which means researchers' interest in blended learning research in mathematics learning has increased from year to year.

Table 1. Development of Blended Learning Articles in Mathematics Learning

Publication Year	Amount	Percentage
2011	2	1.48
2012	4	2.96
2013	4	2.96
2014	2	1.48
2015	6	4.44
2016	5	3.70
2017	5	3.70
2018	12	8.89
2019	34	25,19
2020	41	30.37
2021	13	9.63

These results indicate that writing related to blended learning in a certain period is very productive [16]. On the other hand, table 1 shows the information on the linearity of publications which tends to increase.
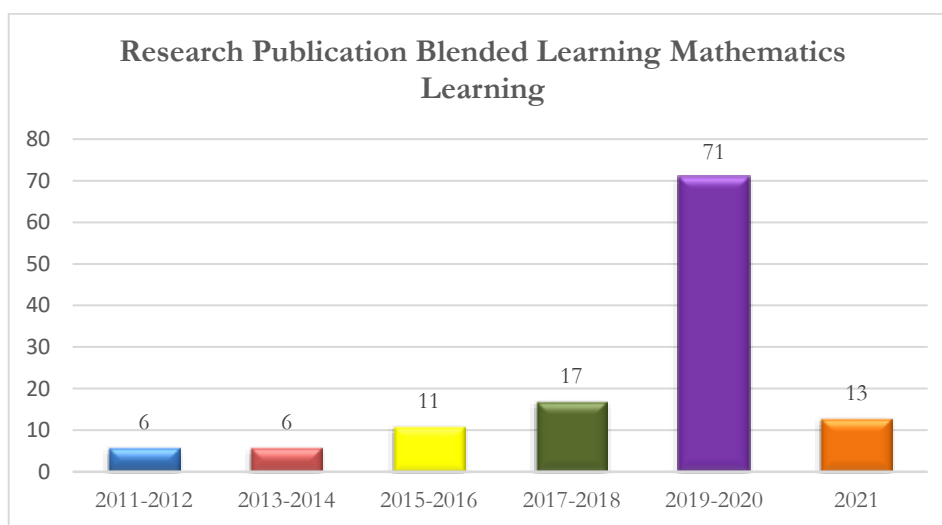

Figure 4. Publication of Blended Learning Articles for Mathematics Learning

Based on the data in Figure 4, which is data on the number of articles on blended learning mathematics learning indexed by Scopus from the first year of the emergence of research publication articles on blended learning mathematics learning, namely from 2005 to the last ten years. It can be seen that this trend pattern shows article writers in various countries. have a higher interest in the study of blended learning mathematics learning. From the data, it can be seen that the highest number of published articles was in the period 2015-2016 and the period 2021. It shows that productivity in scientific publications increased in the 2015-2016 period and the 2021 period, measured by the number of works. Scientific publications in that year experienced an increase because the number of scientific papers published could measure productivity in scientific publications. The topic of publication of mathematics learning blended learning articles in the 2021

period is influenced by the covid-19 pandemic. The application of blended learning mathematics learning is considered an alternative to distance learning during the covid-19 pandemic [18].

The results of the Scopus database search show that the first publication of research on blended learning in mathematics, namely an article entitled "CATIE: A Blended Approach To Situated Professional Development" was written by A. Holmes. in the journal Journal of Educational Computing Research in 2005. Based on these data, it can be seen that technological developments have led to the interest of researchers in publishing research articles related to blended learning in mathematics at both the school and university levels.

For citation analysis, how often work is the subject of discussion or discussion among scientists can be seen from how often work is cited or quoted [3]. The quality of publishing scientific works is seen, one of them by counting the number of times the work has been cited by other researchers and a work called citation means that it has the meaning of usefulness in the field of science, of course in academic life which is scientific [16].
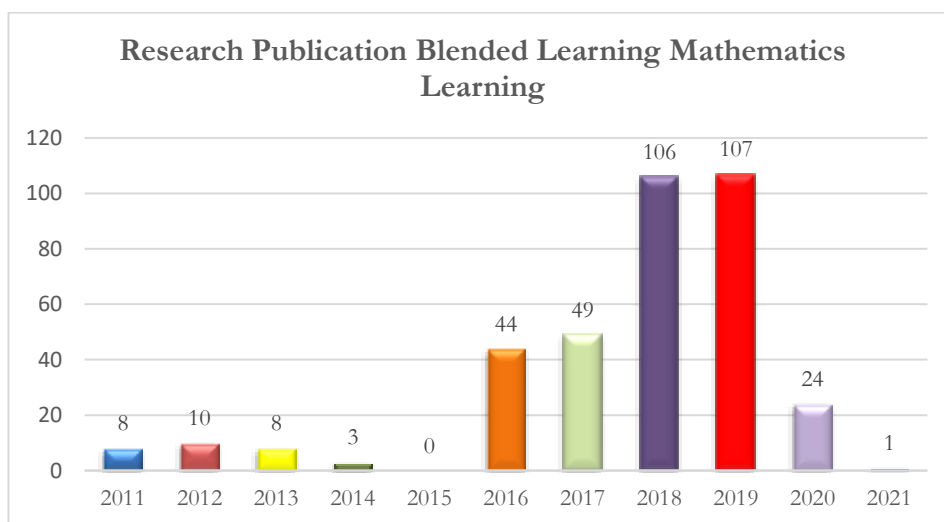

Figure 5. Citation Analysis Diagram for Mathematics Learning Blended Learning Articles 2011-2021

In this study, the citation analysis results show that the number of citations per year from 2011 to 2021 is 360 citations. Quote patterns show different patterns. When viewed from 2011 to 2021, the most citations occurred in 2019 with 107 citations, while the minor citations occurred in 2014 with three citations. The related articles in 2015 are not or have not been quoted, meaning 0 citations. There are several articles on blended learning mathematics that are most cited. From 2011 to 2021, there are three articles with the most citations, namely as follows:

Table 2. Articles with the Most Quotations

No.	Author(s) name	Article Title	Publication Year	Journal Name	Number of Quotes
1	R. Ramadhani	The Effect of Flipped-Problem Based Learning Model Integrated With LMS-Google Classroom for Senior High School Students	2019	Journal for the Education of Gifted Young Scientists	47
2	YW Lin	The Effect of Blended Learning In A Mathematics Course.	2017	Eurasia Journal of Mathematics, Science and Technology Education	31
3	G. Sugiharni	Development of Alkin Model Instruments as Evaluation Tools of Blended Learning Implementation in Discrete Mathematics Course on STIKOM Bali	2018	Journal of Theoretical and Applied Information Technology	11

Based on the data presented in Table 2, it can be seen that the research article with the title "The effect of flipped-problem based learning model integrated with LMS-google classroom for senior high school students" is the article that has the highest number of citations. This can be interpreted as that the article written by Mailizar published in 2019 in the journal Eurasia Journal of Mathematics, Science, and Technology Education is widely used as a reference which results in the writing having a good impact on the creation of knowledge related to blended learning mathematics. This can be the basis for further research.

The keyword trend analysis by the author aims to measure the strength of the term and to count the number of keywords from a research document that appear simultaneously in the article understudy, an analysis that aims to analyze the content, pattern, and trend (trend) of a document set with [19]. Based on the analysis on the VOSviewer software, data obtained from 407 terms, using the minimum number of occurrences or the minimum value of repeated words used is three terms, then determining the most relevant words to be processed as many as 26 terms, then choosing the most repeated word along with the relevance of which is 26 relevant terms. The results of the visualization of the repetition of words in the title are obtained as follows:
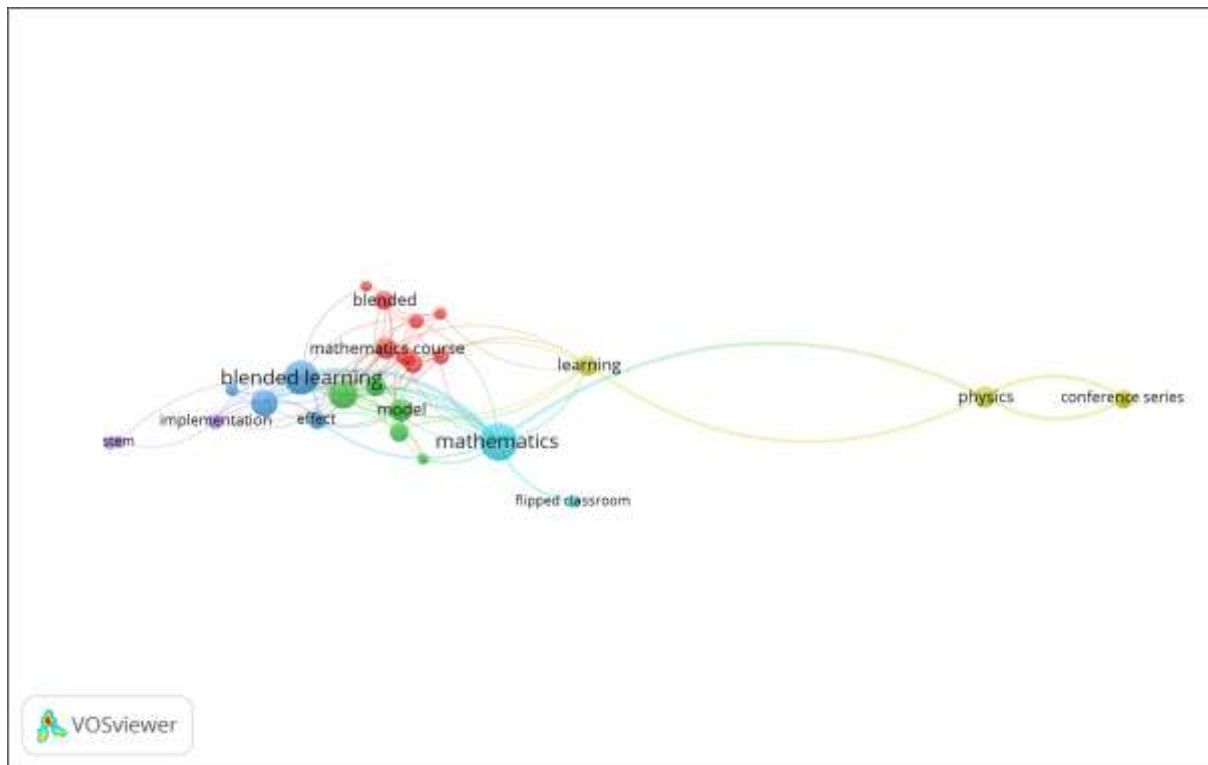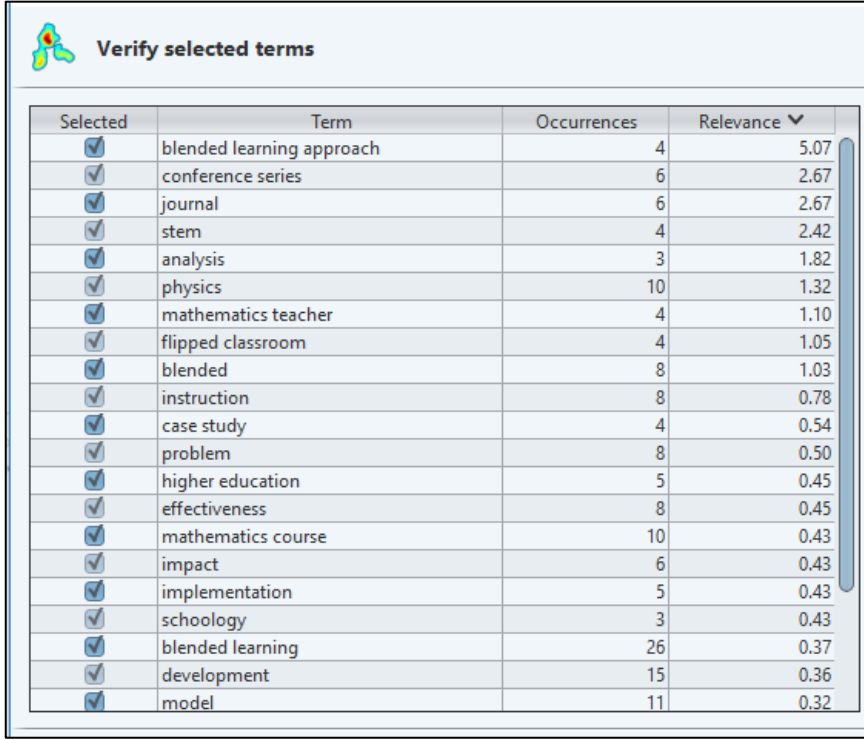
Figure 6. Visualization of the Keyword Network for the Author of Blended Learning
Mathematics Learning

Based on the analysis of the terms or keywords in blended learning articles related to mathematics learning, the most widely used in mathematics learning blended learning articles are "Blended Learning", "Mathematics," and "students". This mapping is carried out to determine which knowledge researchers have widely used in the last ten years. The most dominant research trend is in cluster 1 (red). The details of the 6 cluster keywords from the results of the analysis using VOSviewer are:

1. The first cluster (in red) consists of 8 keywords: analysis, blended, case study, effectiveness, higher education, impact, instruction, and mathematics course. The keyword that often appears is mathematics course.
2. The second cluster (in green) consists of 5 keywords: design, model, problem, Schoology, and student. The keyword that often appears is a student.
3. The third cluster (in blue) consists of 4 keywords: blended learning, development, effect, and mathematics teacher. The keyword that often appears is blended learning.
4. The fourth cluster (yellow color) consists of 4 keywords: conference series, journal, learning, and physics. The keyword that often appears is learning.
5. The fifth cluster (dark blue) consists of 3 keywords: blended learning approach, implementation, and stem. The keyword that often appears is implementation.
6. The sixth cluster (yellow) consists of 2 keywords, namely flipped classroom, mathematics. The keyword that often appears is mathematics.

The following is a summary table of the results of keyword analysis that the author often uses, along with their relevance values using the help of VOSviewer.

Selected	Term	Occurrences	Relevance ✓
☑	blended learning approach	4	5.07
☑	conference series	6	2.67
☑	journal	6	2.67
☑	stem	4	2.42
☑	analysis	3	1.82
☑	physics	10	1.32
☑	mathematics teacher	4	1.10
☑	flipped classroom	4	1.05
☑	blended	8	1.03
☑	instruction	8	0.78
☑	case study	4	0.54
☑	problem	8	0.50
☑	higher education	5	0.45
☑	effectiveness	8	0.45
☑	mathematics course	10	0.43
☑	impact	6	0.43
☑	implementation	5	0.43
☑	schoology	3	0.43
☑	blended learning	26	0.37
☑	development	15	0.36
☑	model	11	0.32

Figure 7. Visualization of the Results of Keyword Analysis that Often Appears and Their Level of Relevance.

Based on the data in the image above, we can say that the rarely used keywords related to blended learning in mathematics are analysis and Schoology. These two keywords can be a reference for further research in the future. Alternatively, it can be said that the topic of Schoology is still not much researched. It indicates that the opportunity to research this topic is still extensive.

CONCLUSIONS AND SUGGESTIONS

Research articles on blended learning mathematics learning published in Scopus indexed journals have generally experienced positive growth from year to year. It shows that articles in various countries have a higher interest in studying blended learning mathematics learning. The data shows that the highest number of published articles was in the 2015-2016 period and the 2021 period. The topic of publication of blended learning mathematics articles in the 2020-2021 period was influenced by the covid-19 pandemic, where the application of blended learning mathematics learning was considered an alternative to distance learning during the covid-19 pandemic. Most citations of articles related to blended learning occurred in 2019, with 107 article citations. The article with the highest number of citations was written by Mailizar which was published in 2019 in the journal Eurasia Journal of Mathematics, Science and Technology Education, many of which were used as references which resulted in the writing having a good impact on the creation of knowledge related to blended learning mathematics learning and research opportunities. It can be the basis for further research. Based on the analysis of keyword trends by the author, it is known that the keywords that are rarely used related to blended learning in mathematics are analysis and Schoology. These two keywords can be a reference for further research in the future. Alternatively,

it can be said that the topic of Schoology is still not much researched. It indicates that the opportunity to research this topic is still extensive.

Based on the studies carried out, the authors suggest that further studies be carried out using different methods and databases, such as Google Scholar or others, to obtain a more comprehensive knowledge mapping.

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