Mapping Science, Technology, Engineering, and Mathematics (STEM) Research on Physics Topics Using Bibliometric Analysis

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Abstract: This study aims to provide an overview of physics learning research using the STEM approach in Indonesia. This study uses a descriptive qualitative method which aims to determine the depth of research using a certain matrix so that a conclusion can be presented. This research uses the Publish or Perish application to search for scientific articles. Search for scientific articles indexed by Google Scholar with a publication range between 2018-2022. The results of the search obtained 107 scientific articles that match the search keywords. Furthermore, from 107 scientific articles, a more in-depth screening was carried out so that 45 scientific articles were obtained that specifically discussed STEM Education in physics. The analysis was carried out using the VOS viewer application with the aim of mapping the direction of the research using the keywords "STEM Education" and "Physics".

Keywords: STEM Education; Physics; Bibliometric Analysis; Publish or Perish (PoP); VOSviewer

Introduction

Many developing countries are conducting research to improve student achievement and the quality of STEM (Science, Technology, Engineering, and Mathematics)-based education. The STEM-based education system has received full and significant support in America and the European Union (Corlu & Aydin, 2016). In the STEM system there are six main pillars, namely: higher-order thinking skills, inquiry-based learning skills, problem-solving skills, contextual learning, collaborative learning and project-based learning. The STEM system can be applied to elementary school (SD), junior high school (SMP) and senior high school (SMA) students.

The current education curriculum in Indonesia is the Freedom to Learn curriculum, which is an option that can be implemented by education units. The Education Unit can implement the Free Learning and STEM curricula simultaneously. But there is still much debate about the lack of student interest in STEM. The lack of student interest in STEM can be seen from the following studies. Yung's research (2010) found that only five percent of students in the United States continue their undergraduate studies in science programs (Yang, 2010). In England, when children enter secondary school, their interest in science topics begins to wane (Barmby et al., 2008).

The reason for students' lack of interest in STEM is because they feel anxious due to the perception that it is too difficult to get good grades in STEM subjects on the topics of Physics, Chemistry and Mathematics. The reduced number of academics in science learning is caused by fear and lack of confidence in STEM-related subjects (Amelia et al., 2019). Because learning science is considered to have a learning syllabus that is difficult and different from other learning materials. There is also an opinion that students who will continue their undergraduate education will have difficulty using STEM learning (Ring et al., 2017). Negative brush

against STEM learning will be a barrier for children pursuing STEM careers (Sin et al., 2013).

By considering some of the aspects above, the author in making this article aims to provide a bibliometric analysis of STEM-related literature on Physics topics indexed by Google Scholar (GS). Through analysis and categories based on distribution and author affiliation. This analysis could become a research topic that is the subject of more publications and the topic "STEM Education on physics" in the future. The methodology used to carry out the analysis is to use bibliometric analysis, including the instruments and methods in which there is a Publish or Perish (PoP) software application. Then to present the results of data processing using the VOSviewer application followed by a discussion session and conclusions from the results of the literature test that has been carried out.

Method

In this research the writer uses descriptive qualitative method. Qualitative descriptive method is a research method that utilizes qualitative information and is described descriptively. This method began to be developed by experts around the 1970s marked by a book entitled "The Discovery of Grounded Theory" written by Glaser and Strauss in 1967 (Packer-Muti, 2016). Descriptive research is a type of research that produces conclusions through a description of the problem and not through a statistical calculation process. Some advantages in the decision-making process, using qualitative methods for assessment and testing. In descriptive research to gain deeper insight into designing, administering, and interpreting assessments and tests and exploring behavior, perceptions, feelings, for the understanding of test takers.

Some of the weaknesses in descriptive research are smaller sample sizes and time consuming. Quantitative research methods, on the other hand, involve a larger sample, and do not require a relatively longer time for data collection (Rahman, 2016). This is also in line with qualitative research which aims to answer questions related to the development of understanding the dimensions of meaning and experience of human life and the social world (Wohlrapp, 2014). In addition to using descriptive methods in this study also use Bibliometric Analysis. Bibliometric analysis is based on a systematic and explicit method (Garza-Reyes, 2015) as well as a method that maps on Knowledge Constraints (Tranfield et al., 2003). In mapping the Bibliometric Analysis there are 5 steps that must be carried out as shown in Figure 1.

Figure 1. Stages of Bibliometric Analysis

Bibliometric analysis stages as shown in Figure 1 are as follows:

1. Determining the Search Database

At the stage of determining the search database, the Publish or Perish (PoP) application is used to make it easier for researchers to find articles that have been published. The Publish or Perish (PoP) application can be used to retrieve scientific article publication meta data from crossref, Google Scholar, PubMed, Open Alex, Scopus, Semantic Scholar, and Web of Science. In this study, the search for articles using the Google Scholar database. The choice of the Google Scholar database is because Goole itself is a popular search engine and is rich in indexed scientific articles (Aulianto et al., 2019; Saputro, 2022).

2. Define Keywords

The second stage in the bibliometric analysis is to determine the keywords that will be used to search the meta data. Determination of these keywords is very important to produce quality journal articles. The keywords used can also be combined using the conjunction "and" or "or". For keywords that are more than one word can be enclosed in double quotation marks, for example the word "STEM Education".

3. Organizing Search Results

The third stage is compiling search results using the PoP application which was carried out in the second stage. Search results can be exported into documents with the extension Research Information System (RIS), BibTex, CSV, Endnote and other formats. Furthermore, these search results can be completed and processed using the Mendeley or Zotero applications to complete the details of each article easily and quickly.

4. Statistical Data Compilation

The fourth stage is to compile statistical data from search results. In this stage, the Excel application can be used to process statistical data. Statistical data compilation can be done easily using the excel application, for example displaying the 10 most cited

articles, displaying the number of articles per year and displaying articles based on certain keywords.

5. Data analysis

The final stage is the analysis of search results data using the PoP application. In this stage the author uses the VOSviewer application to display network visualization between keywords. The results of network visualization between keywords are then followed by analyzing the interrelationships between keywords. Gap analysis can also be carried out or the distance between keywords to determine the updating of related studies.

Result and Discussion

The search results for articles using the Publish or Perish (PoP) application with the Google Scholar (GS) database get 107 articles from 2018-2022. Use the STEM Education keyword in the keyword column, and Journal keyword in the publication name. Can be seen in Figure 2 the search results, the names Diana Bogusevschi, Cristina Muntean and Gabriel-Miro Muntean with the article title Teaching and Learning Physics using 3D Virtual Learning Environment: A Case Study of Combined Virtual Reality and Virtual Laboratory in Secondary School have received the most citations i.e. 124 for articles published in 2020.
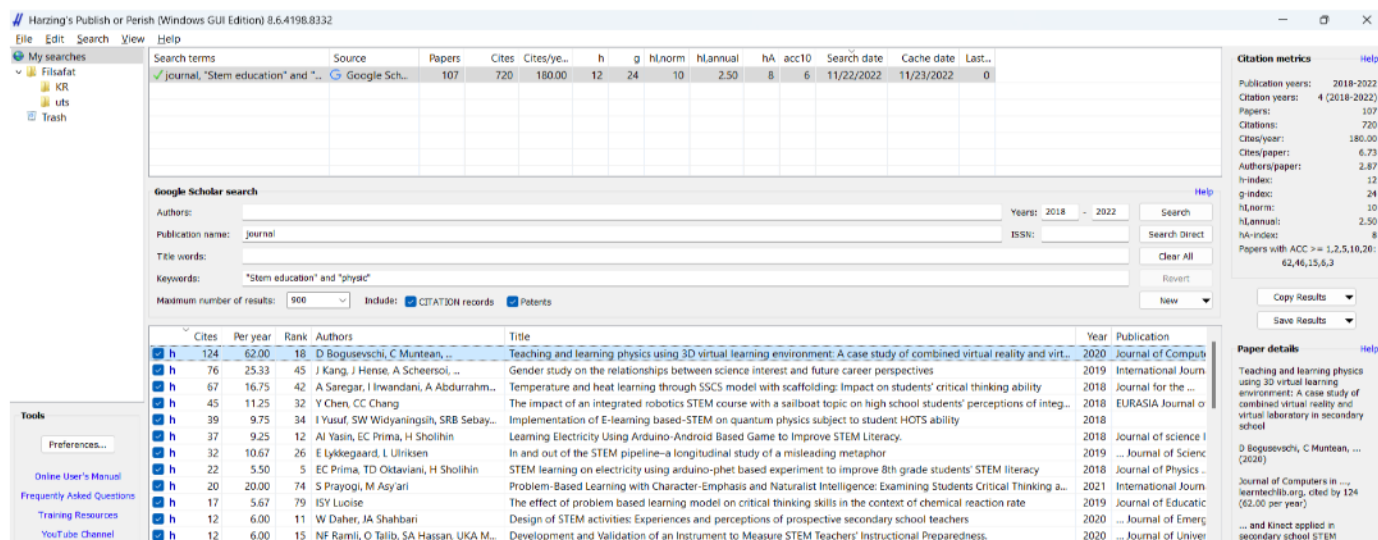

Figure 2. Article search results in Publish or Perish

A total of 107 articles were produced which were further analyzed in more depth and detail to produce relevant research. The author selects and searches for articles that have the keyword "STEM Education" with the results of 45 relevant articles. The search matrix that has been carried out can be seen in Table 1 of the Data Matrix.

Table 1. Data Matrix

Data Metric	Initial Search	Improved Search
Publication years	2018-2022	2018-2022
Papers	107	45
Citations	720	278
Cites/year	180	69.5
Cites/paper	6.73	6.18
Authors/paper	3.42	3.65
H Indeks	12	8
G Indeks	24	15
Hi Norm	9	6
Hi Annual	2.25	1.5

The next step is to take the 10 articles with the highest citation value using the keyword "STEM Education" as shown in Table 2.

Table 2 The Top Ten Highest Citation Articles

Authors (Year)	Title	Journal	Cites	publisher
(Bogusevschi et al., 2019)	Teaching and Learning Physics using 3D Virtual Learning Environment: A Case Study of Combined Virtual Reality and Virtual Laboratory in Secondary School	Society for Information Technology & Teacher Education International Conference	124	learntechlib.org
(Kang et al., 2019)	Gender study on the relationships between science interest and future career perspectives	International Journal of Science Education	76	Taylor &Francis
(Saregar et al., 2018)	Temperature and heat learning through SSCS model with scaffolding: Impact on students' critical thinking ability	Journal for the Education of Gifted Young Scientists	67	dergipark.org.tr
(Chen & Chang, 2018)	The impact of an integrated robotics STEM course with a sailboat topic on high school students' perceptions of integrative STEM, interest, and career orientation	Eurasia Journal of Mathematics, Science and Technology Education	45	ejmste.com
(Yusuf et al., 2018)	Implementation of E-learning based-STEM on quantum physics subject to student HOTS ability	Journal of Turkish Science Education	39	repository.unipa. ac.id
(Yasin et al., 2018)	Learning Electricity using Arduino-Android based Game to Improve STEM Literacy	Journal of Science Learning	37	ERIC
(Lykkegaard & Ulriksen, 2019)	In and out of the STEM pipeline - a longitudinal study of a misleading metaphor	International Journal of Science Education	32	Taylor &Francis
(Prima et al., 2018)	STEM learning on electricity using arduino-phet based experiment to improve 8th grade students' STEM literacy	Journal of Physics: Conference Series	22	iopscience.iop.or g
(Suhirman et al., 2021)	Problem-Based Learning with Character-Emphasis and Naturalist Intelligence: Examining Students Critical Thinking and Curiosity	International Journal of Instruction	20	ERIC
(Dakabesi & Luoise, 2019)	The effect of problem based learning model on critical thinking skills in the context of chemical reaction rate	Journal of Education and Learning (EduLearn)	17	edulearn.intelekt ual.org

Furthermore, 45 searched articles using the Publish or Perish application are saved in RIS format, to be processed using the VOSviewer application. In the preparation stage of data processing using VOSviewer, 16 keyword terms were generated as shown in Table 3. There are several keywords, namely approach, class, development, engineering, Indonesia, interest, level, mathematics, n gain, project, science, skill, stem approach, stem education, studies and technology.

The visualization results using the VOSviewer application will obtain a bibliometric map as shown in Figure 3. It can be seen that the visualization network has 3 network clusters with different colors red, green and blue. Cluster 1 contains 7 keyword items, namely: class, Indonesia, level, n gain, skill, stem approach and study in red. Cluster 2 contains 6 keyword items, namely: approach, engineering, mathematics, project, science, and technology in green. Cluster 3 has 3 items, namely: development, interest and stem education.

Table 3. Term Keyword Analysis Vosviewer

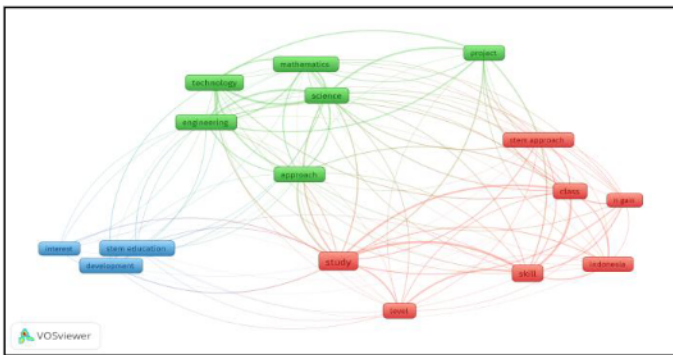| Term	Occurrences	Relevance Score
approach	21	0.4562
class	33	0.8819
development	17	1.3279
engineering	25	1.0368
indonesia	13	1.2041
interest	11	1.9414
level	20	1.1493
mathematics	20	0.496
n gain	11	0.97
project	19	0.3608
science	39	0.953
skill	45	1.4954
stem approach	12	0.4308
stem education	22	1.3013
study	78	0.9141
technology	31	1.081

Figure 3. VOSviewer Network Visualization

Figure 4 shows an overlay visualization of articles per year related to STEM Education keywords. As seen in Figure 4, it shows articles between 2019 and 2021. From the color of the overlay being deep dark in 2019 and starting to lighten in 2021, it means that the keywords technology, engineering, mathematics, science in 2019 have had many articles using these keywords. Furthermore, the keywords skills, stem education are still bright in color, which means that these keywords can still be further researched to produce the latest articles.
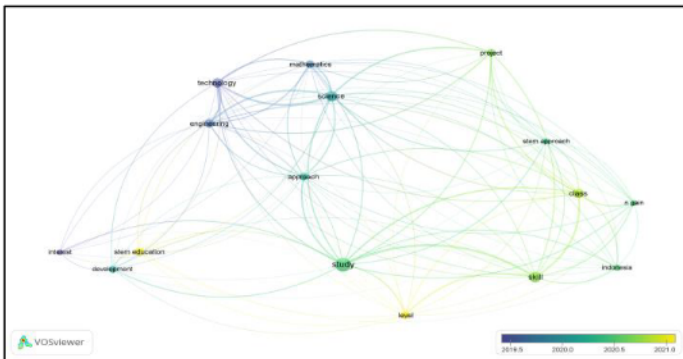

Figure 4. VOSviewer Overlay Visualization

Visualization of density or density, namely the number of articles that discuss STEM Education which are marked with a bright color indicating that there are already many articles with the keywords you are looking for. The dimmer the color density indicates fewer articles using the searched keywords as shown in Figure 5.
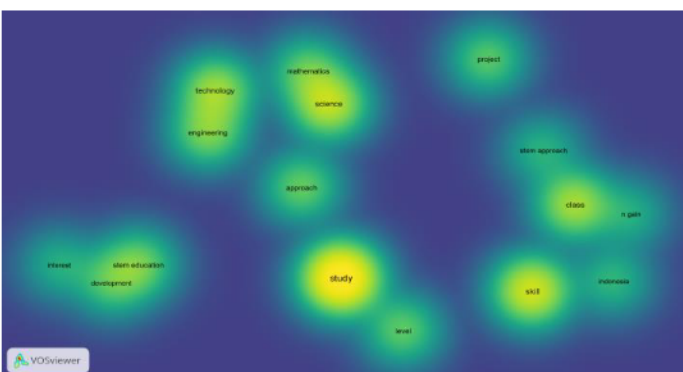

Figure 5. VOSviewer Visualization Density

Bibliometric analysis results generated from Figure 2. The network visualization results of the GS data show that there are 3 clusters which can be seen in Table 4.

Table 4. Three Article Clusters

Cluster	Elemen
Cluster pertama Merah	class, Indonesia, level, n gain, skill, stem approach dan study
Cluster Kedua Hijau	approach, engineering, mathematics, project, science, dan technology
Cluster Ketiga Biru	development, interest dan stem education

Conclusion

From the results of the processing of the Bibliometric analysis that has been carried out, it can be concluded that STEM Education for physics subjects is a theme that can still be developed through the use of technology or projects. As shown in Figure 5, which still shows that STEM Education research has not touched much of it. Hopefully the results of this analysis can be useful and can be used to determine the theme of further research.

In this study, it experienced limitations where the results of research assessments were subjective, especially in determining keywords and determining the range of years used. So, it is still possible for errors to occur in selecting keywords. In addition, considering that the database used in the search only uses GS, the results displayed are limited to GS only.

This research is also an answer to research (Zulaikha et al., 2021) which suggests adding samples to be analyzed so that the authors have broad opportunities to carry out the analysis. Addition of sample articles to more than 200 articles where previously only 45 articles were written. For further research, the authors suggest using a sample of more than 200 articles by compiling search databases using Scopus or web of science and analyzing them using applications such as BiBExcel and HistCite or other applications.

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