Bibliometric Analysis and Research Trends on Problem Based Learning (PBL) Integrated STEM in Physics Learning Layout guide for *Journal of Physics: Conference Series* using Microsoft Word

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Abstract. Physics is one of the subjects that is quite difficult and challenging for students. So we need an approach or learning model to make it easier for students to learn physics. This study examines problem-based learning (Problem Based Learning), which is integrated into Science, Technology, Engineering, and Mathematics (STEM). This study aims to identify trends in the PBL integrated model in physics learning. The method used in this study is the bibliometric analysis method. Articles obtained from google scholar amounted to 980 articles consisting of proceedings and scientific journals, national and international, which were collected from the Publish or Perish (PoP) application. The collected articles were analyzed using the VOSviewer Application to obtain information and synthesize it. The result of this study is that in recent years, Problem Based Learning (PBL) integrated STEM has become one of the trends and has become an option in the implementation of physics learning in schools. This can be seen from the amount of studies and discussions on PBL integrated STEM in physics education. Based on the results of this literature study, several recommendations for further research were also obtained, namely, so that PBL integrated STEM can be even better, it is necessary to try adding various learning media in it, especially electronic modules that develop critical thinking skills.

1. Introduction

Education is the most important thing for society because education allows us to build curiosity and creativity in children, which will lead them to individual fulfillment, problem-solving at the personal, community, or global level, and build creativity and innovation, especially in the field of science. Science is a science in which we learn about natural phenomena around us through a series of processes that we know as scientific processes that will produce scientific attitudes and scientific products, which are composed of the three most essential components in the form of concepts, principles, and theories that apply universally [1].

Learning difficulties are one of the symptoms of the learning process, which is characterized by various behaviors that have a background within and outside of the learner (in this case, students) [2]. Not only students but also the general public have the same interpretation of physics subjects. Some students indicated that physics is one of the most challenging subjects to learn. Not only difficult to learn, but physics has also even become one of the subjects hated by students. The general opinion/view of students and the public is that Physics is a complex subject and most hated by students, exceptionally high school students. This results in students being less motivated to learn physics [3]. Physics learning is still teacher-centered, rote in nature, and has not been linked to real life and technological developments.

Teachers are responsible for the teaching and learning process, so they should understand the problems faced by their students in studying physics. In addition, by knowing the problems faced by students in studying physics, appropriate steps can be analyzed to overcome these problems so that they do not become an obstacle in student learning. Research in the field of education can also test strategies that are more appropriate to the problems that occur so that they are more targeted and valuable in the teaching and learning process.

One of the models and approaches that can be developed by teachers and student-centered is the Problem Based Learning (PBL) model. PBL is a learning model that uses real problems found in everyday life and aims to enable students to build knowledge about science. The PBL model requires students to instill the basics of scientific thinking and develop cognitive thinking, which is very much needed in 21st-century learning [4]. Other abilities that can be developed through the application of PBL

in learning include problem-solving skills, planning, reasoning critically and creatively, stress management, self-assessment, active team collaboration, independent learning, interpersonal skills, decision making, time management, and problem definition skillfully and precisely [5]. The application of learning using PBL can also improve higher-order thinking skills.

In addition to PBL, current learning needs to keep up with the times in the era of globalization, one of which is by integrating Science, Technology, Engineering, and Mathematics (STEM). The linkages between science and technology, as well as other sciences, cannot be separated in science learning. STEM is a discipline that is closely related to one another. Science requires mathematics as a tool in processing data, while technology and engineering are applications of science. The STEM approach to learning is expected to produce meaningful learning for students through the systematic integration of knowledge, concepts, and skills. Some of the benefits of the STEM approach make students better problem solving, innovators, inventors, independent, logical thinkers, and technological literacy [6].

The PBL model can be integrated with the science technology engineering mathematical (STEM) approach. STEM is an effective way to facilitate and maintain the integration of science, technology, mathematics, and engineering [7]. The descriptions of these four terms are: (1) science deals with concepts and laws related to nature; (2) technology is a skill used in knowledge by using an artificial tool that can facilitate work; (3) engineering is knowledge to design a stage/procedure that can solve problems; and (4) mathematics is a science that relates quantities, numbers, and spaces based on logic without any empirical evidence [8]. Integrating PBL with STEM can actualize environmental literacy and student creativity [9]. Applying PBL integrated STEM can also improve students' scientific literacy based on gender and improve students' cognitive, psychomotor, and character abilities [10]. Integrating PBL and STEM requires students' motivation and confidence in advancing their careers [11].

Based on the explanation that has been presented, the author tries to do a literature study. This study examines research trends in physics learning, especially PBL integrated STEM with bibliometric analysis. Organizing and examining research trends can help identify areas of interest from the past and milestones for future research directions. First, researchers can examine important issues in the field of physics education by identifying the extent to which problems are addressed in pedagogical research. Second, information about research physics education trends can be obtained by studying how interest in a topic has changed over time. Third, topics that have been marginalized or neglected can be explored and used in determining future research topics [12].

A review of PBL integrated STEM trends was carried out by compiling results from the scientific journal literature. Representative articles were collected, and data was retrieved using the Publish or Perish (PoP) application. The data is a collection of titles, abstracts, and other data that is searched based on keywords and the limitation of the search time range. Once collected, the data is then processed using the VOSviewer application. VOSviewer is software for creating maps based on network data and for visualizing and exploring these maps. VOSviewer can be used to build a network of scientific publications, scientific journals, researchers, research organizations, countries, keywords, or terms. Items in this network can be linked by co-authoring, co-occurrence, citations, bibliographic merging, or co-citing links. Data from Web File Science, Scopus, PubMed, RIS, or Crossref JSON can be used to build a network. VOSviewer is used to view the relationship between documents. This trend review significantly contributes to the literature, listing articles individually and categorizing them by features.

This review also discusses articles with an inductive approach by focusing on the current situation, advantages, and challenges associated with PBL integrated STEM in physics learning and examines the PBL integrated STEM learning model. This study aimed to identify trends in PBL integrated STEM in physics learning. The method used is the bibliometric analysis method. Bibliometric analysis is applied to measure and quantitatively analyze certain indicators in the published literature in a particular domain and to generate knowledge maps based on large databases. This allows researchers to summarize published information regarding the distribution of articles by year, author, institution, journal, and discipline, a collaboration between authors and institutions, and co-word analysis. The results of this study are expected to provide various information to physics teachers about the trend of PBL integrated STEM so that teachers can find new ideas for improving the quality of physics learning in schools.

2. Methods

This type of research is library research using the bibliometric analysis method. Bibliometric analysis is carried out by looking at the distribution of publications to evaluate the contribution of articles to the advancement of knowledge of various literature using a statistical approach and can provide a broader understanding of all disciplines [13]. The data collection technique of this research used secondary data. The research data is from research articles related to Problem Based Learning integrated STEM in Physics Learning. Data collection was carried out using the Publish or Perish (PoP) application with the keywords "Problem Based Learning integrated STEM" and the limitation of the search time range for the last five years, namely between 2018 and 2022. Then data collection was carried out, and 980 articles were obtained for analysis from proceedings and journal articles. The data for this article is exported in RIS format and will be processed using the VOSviewer application. VOSviewer application is software that can visualize and explore the results of bibliometric studies.

The data analysis technique in this study refers to the results of bibliometric mapping from the VOSviewer application that applies Co-Occurrence calculations. Co-occurrence analysis reveals the research topic statistically, with the condition that the more often the two keywords are paired, the closer the relationship between these keywords [13]. In this analysis, VOSviewer extracts the titles and abstracts of the articles obtained by the binary counting method, meaning that every word found related to one or more topics will be considered one. The minimum number of occurrences of a term is 10, meaning that the word displayed is a word with ten relationships. Therefore, out of 120 words found, only 72 words met the threshold. The following is the flow of data collection and data processing methods that have been carried out:

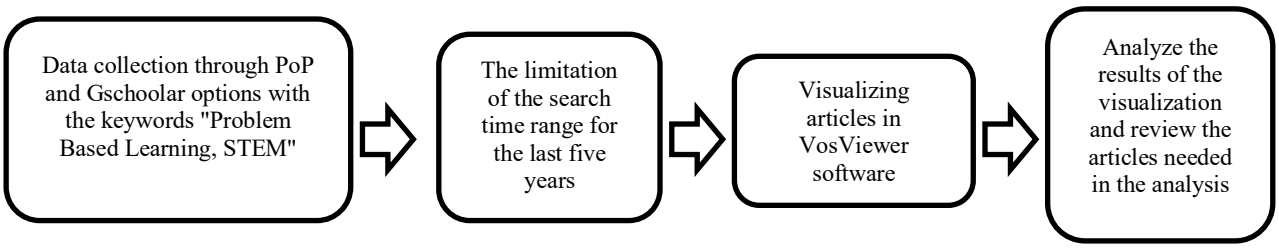

Figure 1. Data collection and processing methods

3. Results and Discussion

The study results obtained at the beginning of the gradual selection using the Publish or Perish (PoP) application obtained 980 articles with PBL integrated STEM keywords. The results of the PoP on Problem Based Learning (PBL) integrated STEM in Physics Learning were analyzed using VOSviewer software. This was done to determine the research variables regarding Problem Based Learning (PBL) integrated STEM in physics learning. Based on the *VOS viewer* mapping, several parameters of the relationship between variables related to learning can be found, including design, research, development, approaches, models, implementation, effectiveness, and learning outcomes. Figure 2 shows the mapping of the similarity of article keywords results, obtained in four groups (clusters) according to each color with 72 related keyword terms regarding Problem Based Learning (PBL) integrated STEM in Physics Learning. The selection of keywords is then carried out according to the research objective: identifying trends in PBL integrated STEM using bibliometric analysis methods. Based on Figure 2, it is known that the red cluster is about the learning model supported by STEM. This is reinforced by the keywords STEM, learning model, and integrated stem education. The green color cluster indicates a relationship between the Problem Based Learning model and STEM. This is indicated by the keywords stem subject, Problem based learning, innovation, and physics. So, in the green cluster, there is a relationship between Problem based learning and STEM. Blue clusters indicate a link between STEM activities; this is indicated by the presence of keywords that are parts of STEM. The last cluster is yellow, which describes active learning, indicated by the keywords active learning and pedagogy.

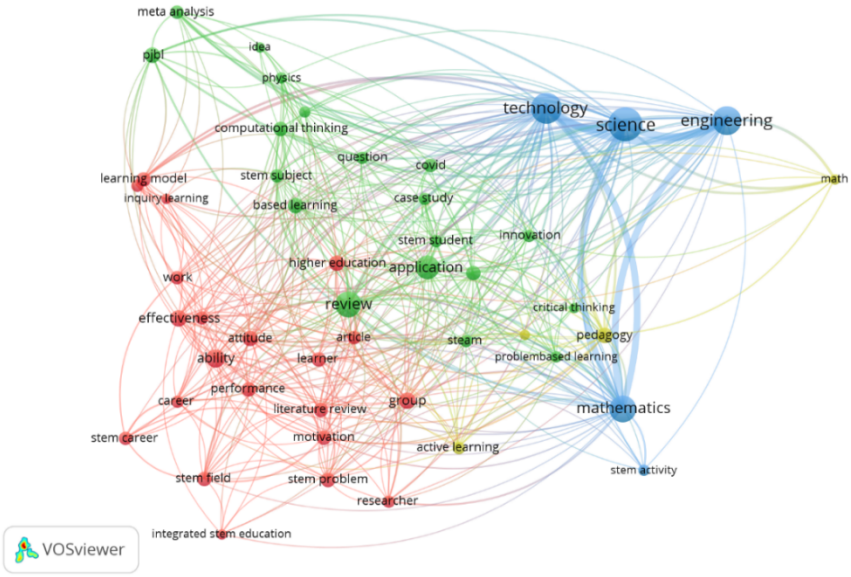

Figure 2. Keyword network visualization map

The larger the circle on a keyword, the more widely used by the article's author, and it has a strong relationship with other keywords. Figure 2 has a large circle for each cluster, namely Problem Based Learning and STEM, which shows a relationship between Problem Based Learning (PBL) and the STEM approach. Even the integration of the PBL model and the STEM approach is one of the preferred learning models that can be implemented among the existing learning models. From the results obtained, it can be seen that the Problem-based learning model can be integrated with STEM. The keywords Problem based learning and STEM are related to critical thinking skills. That way, these models and approaches can improve 21st-century capabilities of Critical thinking, Collaboration, Creativity, and Communication. When combined with other learning models such as PBL, STEM learning can foster positive things such as improving students' critical thinking, creativity, communication, and collaboration needed in this 21st century. From Figure 2, it can be seen that there is a relationship between PBL-STEM and active learning so that the model can be used to develop teaching materials in the form of LKPD or learning modules.

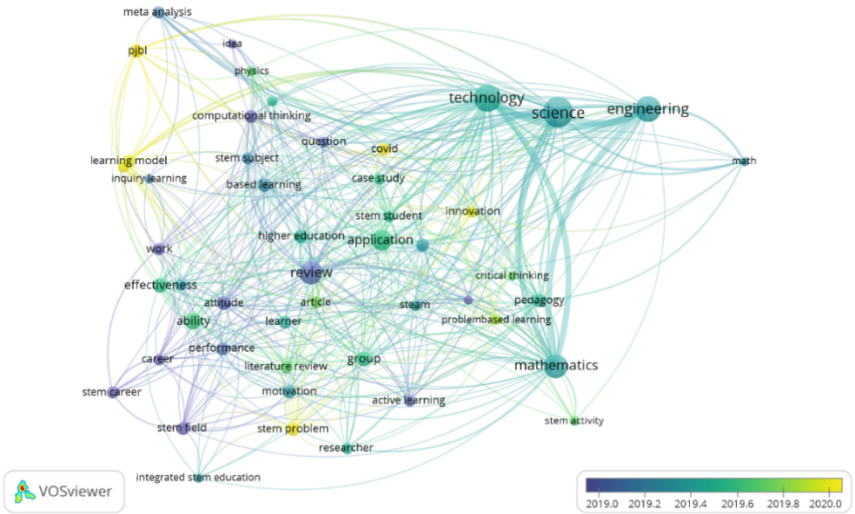

Figure 3. Overlay Problem Based Learning (PBL) integrated STEM

Based on Figure 3, the overlay visualization analysis describes the evolution of the focus of research topics on PBL integrated STEM in physics learning during the 2018-2022 period. In the figure, the bluish nodes represent popular (i.e., frequently used) keywords at the beginning of this period, while the yellowish nodes account for more recent popularity. It was found that the keyword Problem-Based Learning was published in mid-2019, and the STEM subject was published in 2019. The latest articles (2018 to 2022) were mostly related to STEM, Problem, Learning model, innovation, and critical thinking (yellow circle). This data can reference that research trends related to PBL integrated STEM have much to do with these keywords. This data can be used to conduct new research that connects the Problem Based Learning integrated STEM model.

Figure 4. Keyword Density Visualization

The density visualization analysis (figure 4) shows that the lighter the color, the more often the keyword is used. Of all the keywords obtained, no keywords mention student achievement in developing 21st-century skills. This opportunity is a new thing for further research, namely developing learning methods, Problem Based Learning integrated STEM and student achievement in developing 21st-century skills. Figure 4 shows one of the keywords, namely critical thinking skills that can be improved through PBL integrated STEM learning models and approaches. It can also be seen that the keyword critical thinking will be used around 2020. This shows that there have not been too many Problem Based Learning (PBL) integrated STEM studies that have observed an increase in critical thinking skills. This is also an opportunity for further research to try and find alternative learning media that can be used in Problem Based Learning (PBL) integrated STEM. Thus, the learning process and the expected results will be even better in improving students' critical thinking skills. PBL-STEM learning is a learning system based on the philosophy that students can absorb lessons if they can capture the meaning in the academic material they get. Students can capture meaning in school assignments when linking new information with previous knowledge and experience [14]. Critical thinking is a systematic process that provides opportunities for students to formulate and evaluate their beliefs and opinions. Critical thinking

is a process of thinking that is precise, directed, reasoned, and reflective in making reliable decisions [15].

The keyword innovation (innovation) takes a learning media such as learning modules. A learning module is a tool that can transfer messages or information from an educator to students, which aims to facilitate the learning process in the classroom. Using the learning module during the learning process in the classroom, it is hoped that the thoughts, feelings, concerns, and interests of students can be raised, and students can receive and understand the subject matter from the teacher well. In this digital era, an educator must be an expert in creating creative and innovative learning modules based on electronics.

4. Conclusion

Based on the results and discussions that have been carried out, identifying trends in PBL integrated STEM using bibliometric analysis, it can be concluded that in recent years PBL integrated STEM learning has become one of the trends and has become an option in the implementation of physics learning in schools. This can be seen from the many studies, studies, and discussions on PBL integrating STEM in physics education. In future research, it can be done with an integrated PBL-STEM model to improve critical thinking skills and use these models and approaches to develop learning modules.

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