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Problem-based science learning in elementary schools: A bibliometric analysis

Anenggar Dewi Puspita, Ika Maryani, Hanum Hanifa Sukma
Elementary Teacher Education, Faculty of Teacher Training and Educational, Universitas Ahmad Dahlan, Yogyakarta, Indonesia

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ABSTRACT

This study aimed to identify publication trends and recommendations for problem-based science learning research in elementary schools. We used a mixed-methods research design in which descriptive, qualitative, and bibliometric analyses were used to look at the data. We selected the sample by using the purposive sampling technique. Secondary data contains Sinta-indexed research articles published in the Google Scholar database. Data were analyzed using content analysis and the VOS-Viewer. The results of the analysis show that between 2017 and 2021, 98 articles have been published with the keywords [problem-based learning] and [IPA or science learning] in national and international journals with research settings in Indonesia. Most publications occurred in 2020. The keywords that appear the most in the published articles obtained are [problem-based learning], [learning outcomes], [critical thinking skills], and [science learning]. The keyword [*Tri Hita Karana*], or three causes of well-being, appears, but with weak nodes. These keywords appear in many publications whose research settings are in Bali because they are ethnoscientific findings from that area. Weak nodes have several conjectures, namely that this theme has been researched to saturate or that research on this theme is still rarely carried out. This research contributes ideas for future research involving the theme of problem-based learning in science.

Corresponding Author:

Ika Maryani
Elementary Teacher Education, Faculty of Teacher Training and Educational Sciences
Universitas Ahmad Dahlan
Ki Ageng Pemanahan Street No.19, Sorosutan, Yogyakarta, Indonesia
Email: ika.maryani@pgsd.uad.ac.id

1. INTRODUCTION

Education is the process of acquiring scientific skills. It provides each individual with academic knowledge, social skills, the ability to explore one's potential, and the ability to use technology [1]. In an educational institution, educators and students have a mutually beneficial relationship. The method of teaching knowledge can be complicated at times in order to attain learning objectives [2]. The role of education in creating a quality generation is inextricably linked to the quality of learning. Learning contributes to the development of pupils' potential, personality, intelligence, and character [3]. Learning is a two-way interaction in which the teacher offers material, and the students receive the material being taught [4]. Learning can also be viewed as a stage in which the learning environment is regulated and conditioned to promote student character.

Learning is help given to pupils by educators to ensure that the process of acquiring knowledge goes smoothly [5]. An effective learning process positively impacts students' abilities and personalities. Learning builds students' strong characters [6], [7], allowing them to assimilate into their social surroundings.

Learning activities are deemed effective when designed according to the student's performance level [8]. Elementary school students receive learning that underpins the delivery of knowledge [9]. Learning at the elementary school level must focus on student qualities, especially being energetic and curious.

Elementary school students enjoy learning that includes games [10], [11]. Learning while playing helps children learn and absorb information more enjoyably and effectively. Elementary school students think in concrete and logical ways; thus, they understand things realistically [12]. Elementary school students learn by gaining knowledge through hands-on activities [13]. Pupils in elementary school have excellent observational abilities, so educators must be able to design learning that supports the development of students' observational skills.

Schools play a significant role in shaping students' character and personalities [14]. A student character created during the learning process represents a school system. The role of the teacher in the learning process cannot be isolated from the quality of an education system [15]. The learning model the teacher uses in the classroom has a significant impact on the learning process. A learning model should depict a systematic method to assist students in achieving the learning objectives [16]. It refers to a method, strategy, model, or technique for facilitating communication in the classroom. Teachers should develop the learning model in such a way as to help students achieve the previously established learning objectives. Experts have created many learning models based on learning principles, psychological theory, sociological theory, and supporting system analysis [17]. A learning model approaches the learning process to promote students' active participation, attitudes, and knowledge.

Learning models aim to facilitate the delivery of learning materials and realize predetermined learning strategies [18]. Besides optimizing learning outcomes, learning models can also provide teachers and students with a broad picture of learning philosophy [19]. Optimizing the learning model's implementation will increase students' motivation to achieve higher learning outcomes [20]. It should be noted that the learning model used in class must be designed with the nature and type of information to be taught in mind so that the inter-factors that make it up function as a unified whole. The unity of this learning model will later impact how students perceive learning material and reach learning goals. In the learning process, many different types of learning models can be used. However, a teacher must carefully select and implement the appropriate learning model to provide students with a positive learning experience.

Teachers must be able to choose learning concepts that stimulate students' critical thinking skills. Problem-based learning (PBL) is an example of a learning approach that is suitable for the concept. Problem-based learning is an instructional approach that uses everyday problems to train students' critical thinking skills [21]. PBL allows students to investigate and evaluate the situations presented by the teacher [22]. The steps in the problem-based learning model involve providing students with problem orientation, arranging for students to conduct research, requiring students to conduct analysis independently and in groups, and motivating students to develop and present the outcomes of the analysis. At the final stage of PBL, the teacher and students analyze and draw conclusions based on the problem-solving results [23].

The teacher serves as the learning facilitator in PBL, allowing students to actively participate in the learning process [24]. Problem-based learning has been shown to improve students' knowledge and comprehension of concepts or ideas [25]. PBL requires students to identify and solve problems [26]. This problem-solving process will sharpen students' critical, observational, active, and creative thinking abilities, allowing them to identify solutions to these problems. Problem-based learning includes activities that are quite similar to the concept of learning science. Learning science in elementary school, for example, teaches pupils how to solve issues and think critically and rationally.

Science education should enable students to apply scientific concepts to real-world problems. As a school subject, natural science teaches students how to interact with their surroundings [27]. Science education builds students' attitudes, nimble skills, far-reaching ideas, and problem-solving skills. Science education must also be able to develop students' skills to solve problems with reasoning and analysis [28]. Science learning involves experimental activities or observations of natural occurrences that assist students in developing a working knowledge of science [29]. Problem-based learning (PBL) integrated into science classes can engage students in active learning.

Education research will continue to establish new networks to discover new research breakthroughs. It is impossible to deny that educational research is a rapidly developing subject of study. Many studies have been carried out to investigate the integration of the PBL model and the science learning (IPA) technique. Researchers around the world have been studying the effectiveness of PBL in science education. As a result, we should investigate the literature on the topic under consideration. The literature in this section is meant to expand on findings related to a theme. Bibliometric analysis is one of the techniques of analysis that can be used in a literature review. Bibliometric analysis can be used to assess the productivity of writers, organizations, and cross-theme collaborations [30].

A bibliometric analysis contains bibliographic studies or scientific activities carried out by a researcher [31]. It refers to a method for determining the publishing trend of a variable using a statistical or mathematical methodology [32]. The bibliography collection is evaluated to create publication trend maps, which are movements in a phenomenon, to find out the most recent information. A bibliometric analysis employs a quantitative approach to examine publication patterns such as subjects, authors, citations, titles, and other factors [33]. The current study examined a collection of published articles to see if there were any trends in the related variables. The articles were sorted according to predefined criteria. The VOS-Viewer program was used to process the data. The VOS-Viewer displays were evaluated to discover the trends of the connected variables. The findings of this study will be useful to other scholars looking for literature or references on the integration of PBL and natural sciences in elementary schools.

2. RESEARCH METHOD

This study employed mixed methods, combining descriptive and bibliometric analysis. The research sample was determined using a purposive sampling technique. The secondary data sources for this study was the Google Scholar database, which includes papers published in national and international journals. The national journals that published these publications are accredited on a national level (Sinta 1–5). Meanwhile, the international journals that were reviewed must be indexed by Scopus. The articles were published between 2017 and 2022. This study examined 98 articles that were sorted using predetermined criteria.

Data analysis was assisted by VOS-Viewer and Mendeley. The data analysis consisted of several stages. First, we collected articles that contain topics that are in line with the research objective. Following that, we examined and sorted the articles based on the criteria that had been set before transforming the article format to RIS using Mendeley. The data in the RIS form was then processed using the VOS-Viewer tool with the co-occurrence analysis type setting and full-count calculation method, resulting in a minimum of two keywords being displayed (a total of 22 keywords). The VOS-Viewer visualization was analyzed to answer the research question. The results of data analysis on VOS-Viewer were network mapping images containing 22 networks and seven clusters of research topics with different colors.

3. RESULTS AND DISCUSSION

3.1. The development of research on the application of problem-based science learning in elementary schools

We first discovered 14,500 articles with the keywords [*penerapan problem-based learning IPA di sekolah dasar*] or 'the implementation of problem-based science learning in elementary schools'. Then, the articles were sorted depending on the journals' accreditation. Articles from national journals indexed by Sinta 1–5 and international journals indexed by Scopus were used in this study. In this investigation, 98 publications met the criteria for journal accreditation. Figure 1 depicts the rise in the number of research papers published on problem-based science learning in elementary schools from 2017 to 2020. However, the number of publications on this topic decreased significantly between 2018 and 2019.

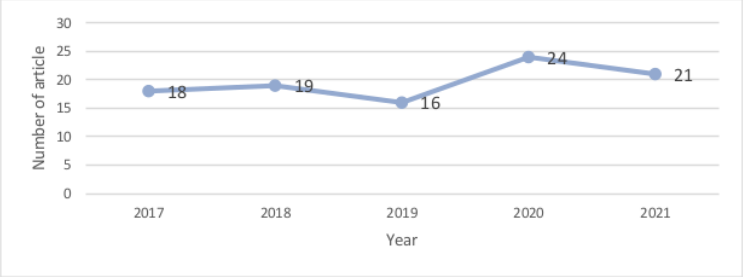

Figure 1. Number of publications on the PBL in elementary schools in 2017-2021

Every year between 2017 and 2021, a different number of articles about the implementation of problem-based science learning in elementary schools were published. The year with the most publications

(24 publications) was 2020, while the year with the fewest publications (16 publications) was 2019. In 2017, eighteen articles on PBL science in primary schools were published in national and international journals, followed by 19 in 2021 and 21 in 2021. The data reveals that the number of publications on the implementation of PBL science in elementary schools has fluctuated between 2017 and 2021. The quantity of this publication can serve as an indicator of the current year's research trends [34].

3.2. Specifications of national and international journals publishing articles on the implementation of problem-based science learning in elementary schools

This analysis employed articles from national journals indexed by Sinta 1, Sinta 2, Sinta 3, Sinta 4, and Sinta 5 and international journals indexed by Scopus. In this investigation, 98 articles from the Google Scholar database met the journal accreditation criteria. Researchers in Indonesia use the Scopus and Sinta indexes to measure different things [34]. While Scopus is a global index that covers a wide range of disciplines and journals [35], Sinta is focused solely on research output in Indonesia, isolating the precise impact of SINTA remains challenging [36]. Researchers in Indonesia may use both indices to measure different aspects of their research performance [37], depending on their goals and the audience they are targeting.

3.2.1. Number of articles published in national Sinta-indexed journals

Among the 98 articles used in the data analysis, 9[illegible]rticles were published by national journals indexed by Sinta 1–5. Figure 2 presents a data visualization of the number of articles published in national journals on the application of problem-based science learning in elementary schools. The highest number of publications (23 articles) was found in 2020, followed by 20 publications in 2021. Meanwhile, the lowest [illegible]mber of publications (15 articles) was observed in 2019, 18 articles were published in 2018, and 17 articles were published in 2017. The high number of publications can be attributed to pandemic-era research trends such as online learning. This remote, online learning approach is very suitable for the problem-based learning model [38], [39]. During the pandemic, there has been a huge rise in the use of online learning platforms and technologies, and many researchers have been looking at how well these methods work for implementing PBL in remote settings [40]–[42]. Because there are now a lot more research papers about PBL and online learning. Overall, the pandemic has given researchers and teachers a chance to try out new ways to teach and l[illegible]rn, and online learning has become a big part of this change [43]. As the pan[illegible]emic continues, it is likely that research in this area will continue to grow as educators and researchers seek to improve the effectiveness of remote learning approaches [44] and address the challenges posed by this new educational landscape.

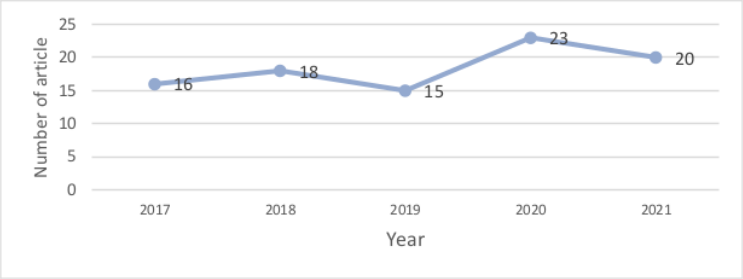

Figure 2. Number of publications on PBL in elementary schools published in national journals

3.2.2. Number of articles published in internati[illegible]al scopus-indexed journals

Figure 3 displays the number of articles on the implementation of problem-based science lea[illegible]g in elementary schools published in international Scopus-indexed j[illegible]rnals. Figure 3 indicates that six articles were published in international journals between 2017 and 2021. The highest number of articles (two articles) published in the journals was found in 2017. From 2018 to 2021, one article was published every year.

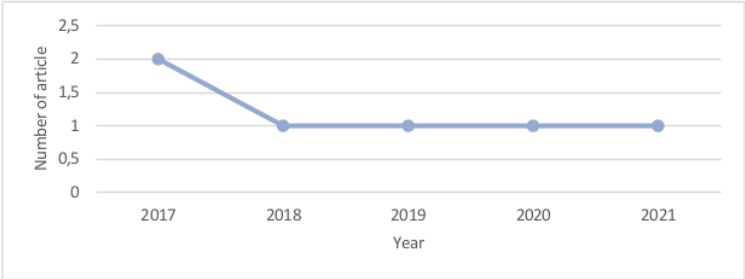

Figure 3. Number of publications of PBL in elementary schools published in international journals

3.3. Trends in research on problem-based science learning in elementary schools on VOS-Viewer

The VOS-Viewer application was used to analyze trends in research on the use of problem-based science learning in elementary schools from 2017 to 2021. Articles chosen based on journal accreditation were then imported into the Mendeley application and saved in the RIS format. Using VOS-Viewer, the obtained data were processed by configuring the co-occurrence computation of complete counting and units of analysis with keywords [45]. This form of analysis can be used to detect patterns and relationships between keywords or terms in a dataset, thereby assisting academics in identifying interesting study themes and areas. By displaying the co-occurrence network, researchers may determine which terms are most closely related and how they are interconnected within the network.

The analysis resulted in 138 keywords in 98 articles on related themes. However, after limiting the number of occurrences to two, we obtained twenty-three keywords. The data visualization was separated into clusters, and each cluster was assigned a distinct color. Each cluster contains similar terms or subjects, as well as keywords that stand out in the set of articles that have been shown. Figure 4 shows the visualization of trends in research on PBL science in elementary schools. Nodes are the keywords that appear in the VOS-Viewer visualization. Each cluster has a different color to represent it in the existing node network. Cluster 1 includes red nodes; cluster 2 includes green nodes; cluster 3 includes dark blue nodes; cluster 4 includes yellow nodes; cluster 5 includes purple nodes; cluster 6 includes light blue nodes; and cluster 7 includes orange nodes. The details of the clusters are shown in Table 1.

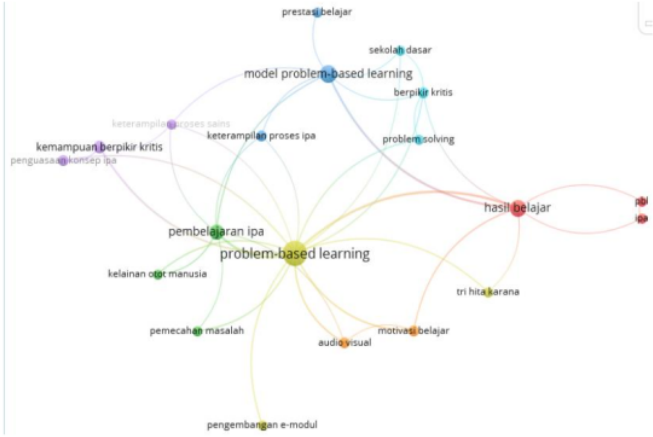

Figure 4. VOS-Viewer visualization on trends in research on PBL science in elementary schools

Table 1. Items contained in the VOS-Viewer visualization clusters

Num	Cluster	Items and occurrences
1	Cluster 1 (red node)	Science learning outcomes (19), critical thinking skills (8), problem-based learning (56), e-module development (2)
2	Cluster 2 (green node)	Learning outcomes (13), science (2), PBL (2), *Tri Hita Karana* or three causes of well-being (2)
3	Cluster 3 (dark blue node)	Science process skills (3), problem-based learning model (15), learning achievement (2)
4	Cluster 4 (yellow node)	Human muscle disorder (2), science learning (10), problem solving (3)
5	Cluster 5 (purple node)	Critical thinking skills (5), science process skills (2), mastery of science concepts (3)
6	Cluster 6 (light blue node)	Critical thinking (3), problem solving (2), elementary school (3)
7	Cluster 7 (orange node)	Audio visual (3), learning motivation (3)

The VOS-Viewer visualization data is reflected in the 'problem-based learning' item, which is linked to other items. In other words, the items associated with the 'problem-based learning' item have the highest level of correlation with other terms. We can see the overlay visualization of its keywords in Figure 5. Occurrences demonstrate how a node is linked to other nodes, whereas strength represents the link's strength, which is estimated based on its existence in the selected article. Based on our findings, we believe that the nodes that appear in a light color are nodes that are infrequently used as research topics. Nodes with faint hues and located far from the dominating node, on the other hand, are frequently used in research, resulting in saturated study subjects. This possibility exists because there is no guarantee in VOS-Viewer that the nodes placed at the edge of the image are the nodes that are rarely used for whatever reason. As a result, researchers must be able to assess data based on factual data in the field in order to provide recommendations for study trends that are relevant to the needs of researchers and have the potential to be investigated in the future.

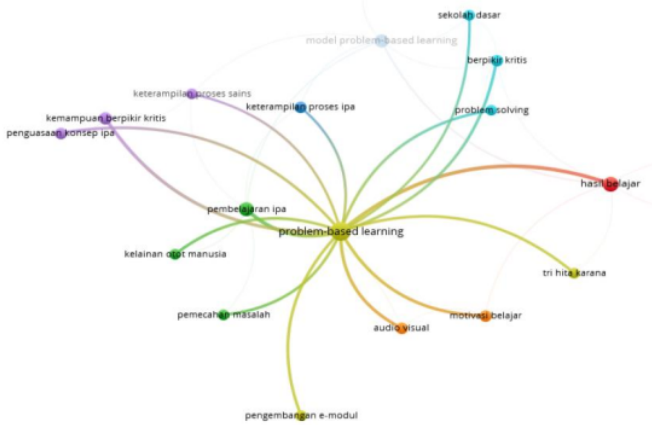

Figure 5. The overlay visualization of the keywords [*problem-based learning IPA di sekolah dasar*] or the implementation of problem-based science learning in elementary schools

The overlay visualization shows that the [*Tri Hita Karana*] node is associated with the [problem-based learning] item with two occurrences and three total strengths. The findings of occurrences and strengths indicate that [*Tri Hita Karana*] is one of the items developed in earlier years of research. However, according to Google Scholar statistics, which include 6,000 publications, the topic has received little attention in the past five years. Thus, we recommend the item [*Tri Hita Karana*] as a research theme for future investigation. The term [*Tri Hita Karana*] refers to a science learning process that can promote students' behavior to appreciate nature and all living things. The overlay visualization of [*Tri Hita Karana*] is shown in Figure 6.

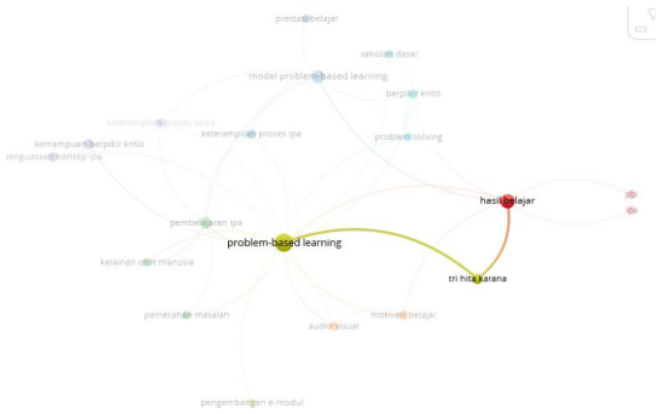

Figure 6. The overlay visualization of *Tri Hita Karana*

Metadata and the VOS viewer show trends in research on the application of problem-based science learning in elementary schools from 2017 to 2021. The analysis's findings offer potential research topics or items for future researchers to explore further. The [*Tri Hita Karana*] is one of the items indicated by the study's findings. The term [*Tri Hita Karana*] refers to a science learning approach that helps shape students' positive attitudes toward nature, including respect for nature and all of its inhabitants. The [*Tri Hita Karana*] is an educational concept developed based on the local wisdom in Bali. This philosophy teaches mankind to live in harmony with God, their fellow humans, including themselves, and everything around them, including the environment. However, the visualization findings suggest that [science process skills], [problem solving], [human muscle disorders], and [e-module creation] have the potential to be further developed due to their low occurrence rates.

4. CONCLUSION

The analysis showed that, between 2017 and 2021, 98 articles on problem-based science learning were published in national and international journals. The highest number of articles related to this topic (23 publications) were published in 2020. The number of publications with the keywords [*penerapan problem-based learning*] or 'the implementation of problem-based science learning in elementary schools' fluctuated every year between 2017 and 2021, but the fluctuation did not occur significantly. The keywords that appear the most in the published articles analyzed in this study are problem-based learning, learning outcomes, critical thinking skills, and science learning. A VOS-Viewer metadata analysis on the keywords [*penerapan problem-based learning IPA di sekolah dasar*] or the implementation of problem-based science learning in elementary schools suggests [*Tri Hita Karana*] as a research subject that should be investigated further. The [*Tri Hita Karana*] refers to a science-based learning approach that helps instill in students a positive attitude towards nature, including respect for nature and all of its inhabitants. The [*Tri Hita Karana*] is an educational concept developed based on local wisdom in Bali. This philosophy teaches humankind to live in harmony with God, those around them, including themselves, and everything around them, including the environment.

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BIOGRAPHIES OF AUTHORS

Anenggar Dewi Puspita s currently studying at the Department of Elementary School Teacher Education, Faculty of Teacher Training and Educational Sciences, Universitas Ahmad Dahlan. Her research interests include science education, the development of science educational tools, and learning interests. She can be contacted by email at anenggar1800005160@webmail.uad.ac.id.

Ika Maryani s a faculty member at the Department of Elementary Teacher Education, Faculty of Teacher Training and Educational Sciences, Universitas Ahmad Dahlan. She has been actively involved in basic education research, particularly that that focuses on enhancing teacher competency and improving students' learning experiences. She graduated from Universitas Sebelas Maret with a bachelor's degree in chemistry education and a master's degree in science education. She earned her doctorate in education from Universitas Negeri Yogyakarta. She can be contacted by email at: ika.maryani@pgsd.uad.ac.id.

Hanum Hanifa Sukma is a member of the teaching staff at the Department of Elementary Teacher Education, Faculty of Teacher Training and Education, Universitas Ahmad Dahlan. She has been involved in basic education research, focusing on improving teacher competence and student learning experiences, as well as teaching Indonesian in elementary school. She graduated from Universitas Sebelas Maret with a bachelor's degree in elementary teacher education and a master's degree in basic education from Universitas Pendidikan Indonesia. She can be contacted by email at hanum.sukma@pgsd.uad.ac.id.

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