Problem Based Learning Model in Natural Science Learning in Elementary Schools: Systematic Literature Review & Bibliometric Analysis

Ramadyani Saskya Ayuni[1*], Shelvilia Putri[2], Syifa Rochmawati Purnama[3], Sendi Fauzi Giwangsa[4]

[1,2,3,4] Universitas Pendidikan Indonesia, Bandung, Indonesia

sendifauzigiwangsa@upi.edu

DOI: https://doi.org/10.21107/Widyagogik/v12i2.28430
Received August 29, 2024; September 28, 2024; Accepted October 17, 2024

Abstract

Problem-Based Learning is a teaching method or model that involves using situations or problems as the starting point for learning. To ensure optimal learning outcomes, an effective approach is to apply a learning model that supports the learning process, one of which is the Problem-Based Learning model. This study aims to identify the implementation of the Problem-Based Learning model in Natural Science education at the elementary school level in improving learning outcomes and 21st-century skills (critical thinking, creativity, and collaboration) by using bibliometric analysis as the analytical approach and Systematic Literature Review with the PRISMA method (Preferred Reporting Items for Systematic Review and Meta-Analysis). The databases used include Publish or Perish and Google Scholar, while bibliometric analysis is conducted using VOSViewer. The Problem-Based Learning model has been proven to enhance critical and creative thinking skills as well as students' learning outcomes.

Keywords – Natural Science; Problem-Based Learning; Elementary School

1. Introduction

Encouraging students to explore natural curiosity, develop questioning skills, and seek answers to natural phenomena based on evidence are the goals of learning, which also aim to foster students' scientific thinking abilities (Triapamungkas, 2022). Fundamentally, the objective of Natural Science education is to educate and equip students with the skills to acquire and apply Natural Science concepts. Furthermore, it involves providing students with foundational knowledge, whether to continue to higher levels of education or to apply it in everyday life. Therefore, teaching this subject at the elementary level is crucial. Critical thinking is closely related to Natural Science learning, as this subject is intertwined with daily life, requires scientific work, and involves numerous experiments in each lesson (Mahpudin, 2018). Critical thinking is not only active but also involves reasoning that is acceptable to the mind. This aligns with 21st-century education, which demands students to possess competencies in critical thinking, creative thinking, communication, and collaboration. According to 21st-century skills, critical thinking involves proficiency in analytical reasoning (Munawwarah et al., 2020).

Through Natural Science learning, students are expected to create works from Natural Science concepts to solve surrounding problems, making learning more meaningful through discovery. They are also encouraged to develop scientific thinking, working, and behaviour, and to communicate their thoughts as life skills derived from scientific processes (Febiani Musyadad et al., 2019). However, Natural Science subjects are often considered difficult by most students, from elementary to secondary school levels. One of the challenges in current education is the weak implementation of teaching processes by teachers in schools (Rifai et al., 2020). Conventional teaching methods still dominate, causing students to depend on teachers and textbooks, lack motivation, engage less actively, find Natural Science unattractive, and seldom use learning media. This affects students' learning outcomes (Wulandari et al., 2017). Ideally, Natural Science lessons should direct students to actively search and practice the subject

matter to provide broader understanding related to the natural environment. This kind of learning is essential for solving daily life problems (Ilhamdi et al., 2020).

Problem-Based Learning (PBL) is a learning model that uses situations or problems as the starting point for instruction (Indrawati & Wardono, 2019). This problem-based model is an innovation in education. Emerging issues need to be addressed by improving students' learning outcomes through instructional designs that actively engage students (Putri & Wardani, 2021). In its application, students' thinking skills are optimized through systematic group or team work, allowing them to continuously strengthen, refine, test, and develop their thinking abilities (Rifai et al., 2020). For this reason, the PBL model is highly suitable for Natural Science education. Learning becomes more meaningful when students are directly involved in solving problems. By actively participating in problem-solving, students are expected to gain a more comprehensive and in-depth understanding of Natural Science (Santosa et al., 2022).

If the imbalance in the learning process or outcomes of Natural Science is not addressed promptly, it could seriously impact the learning process (Puspitasari et al., 2018). To ensure optimal learning outcomes, effective teaching models that support the learning process must be implemented. Among these, Problem-Based Learning stands out as an effective model for improving students' learning outcomes in Natural Science education (Amalia & Hardini, 2020). PBL enhances students' abilities through direct observation, fostering critical thinking to solve problems and encouraging more active participation (Mareti et al., 2022).

Based on the above explanation, a comprehensive analysis of recent literature on the use of the Problem-Based Learning model is needed to enhance the effectiveness of Natural Science teaching at the elementary school level. This study aims to analyse existing literature using a bibliometric approach, focusing on the application of Problem-Based Learning in elementary-level Natural Science education.

2. Method

Bibliometric analysis measures the development of research, literature, books, or documents in a specific field, both quantitatively and qualitatively, using statistical methods (Hakim, 2020). The study applies a Systematic Literature Review (SLR) methodology using the PRISMA approach (Preferred Reporting Items for Systematic Review and Meta-Analysis). This method is carefully and systematically implemented by following appropriate research steps or protocols (Nurdewi, 2022). A Systematic Literature Review involves reviewing, analysing, and evaluating existing research in a structured manner, as well as classifying and categorizing evidence based on prior studies. In this research, the PRISMA methodology is applied by following the stages illustrated in the diagram below:

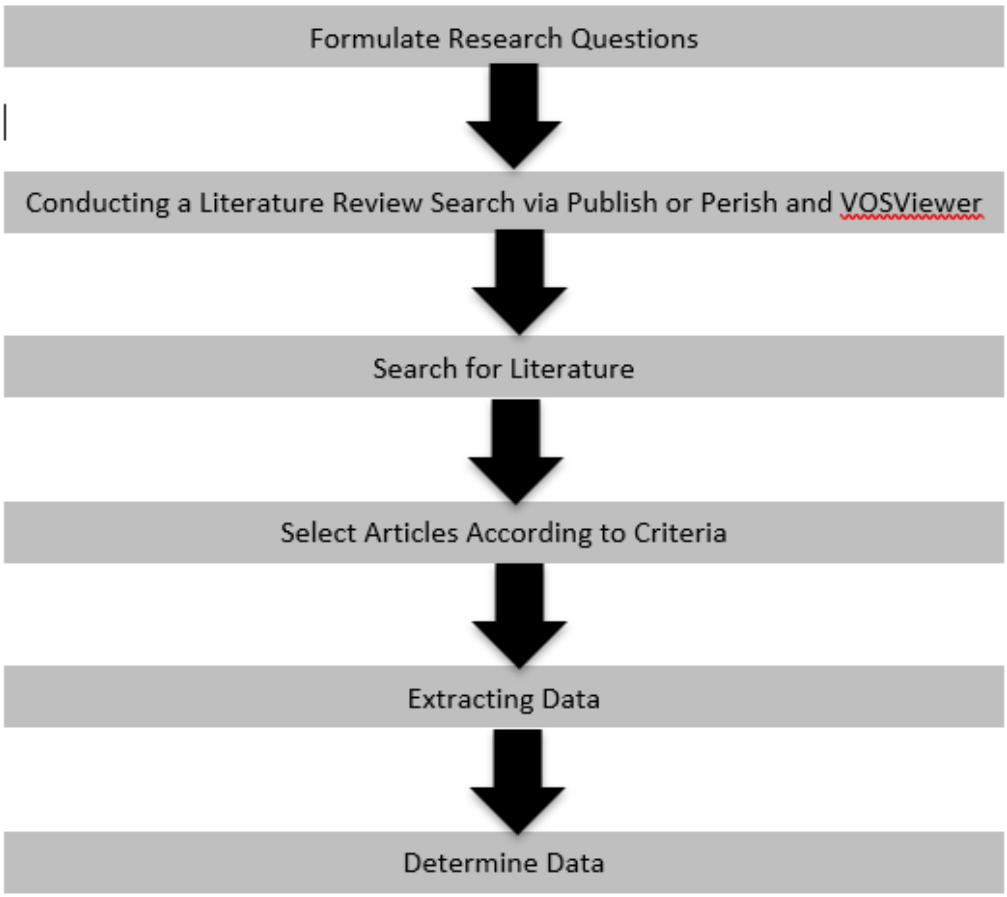

Figure 1. Prisma Systematic literature review model (Linnenluecke et al., 2020; Perry & Hammond, 2002; Wahono, 2015)

Research questions identified are as follows:

Table 1. Research Questions

ID	Research Questions	Objective
RQ 1	How has the annual publication trend of the Problem-Based Learning model in Natural Science education at the elementary level evolved from 2014 to 2023?	To understand the rise and fall in publications related to the Problem-Based Learning model in Natural Science education at the elementary level from 2014 to 2023.
RQ 2	What topics are frequently discussed in the Problem-Based Learning model in Natural Science education at the elementary level published from 2014 to 2023?	To identify the frequently discussed topics within the Problem-Based Learning model in Natural Science education at the elementary level published between 2014 and 2023.
RQ 3	Which articles are most cited in the Problem-Based Learning model in Natural Science education at the elementary level published from 2014 to 2023?	To identify the most cited articles by researchers on the Problem-Based Learning model in Natural Science education at the elementary level published from 2014 to 2023.
RQ 4	How is the implementation of the Problem-Based Learning model in Natural Science education at the elementary level?	To understand the implementation of the Problem-Based Learning model in Natural Science education at the elementary level.
RQ 5	What is the impact of the Problem-Based Learning model in Natural Science education at the elementary level?	To identify the impact of the Problem-Based Learning model in Natural Science education at the elementary level.

Literature Search

This study was conducted during the period of September to December 2024. Articles were collected using the keywords Problem-Based Learning and Natural Science Education in Elementary Schools. The databases used in this study include Publish or Perish and Google Scholar. Additional software applied in this research includes Publish or Perish, VOSViewer, and Mendeley.

Selecting Articles Based on Criteria

The study applied inclusion criteria, where the literature review comprised articles written in both Indonesian and English. The focus of the research was on issues related to the Problem-Based Learning model in Natural Science education at the elementary school level. Data were collected using the Publish or Perish application and the Google Scholar website, then analysed descriptively and qualitatively to identify articles relevant to the 4M objectives: observing,

explaining, classifying, and synthesizing the latest insights through meta-synthesis exploration. Meta-analysis was employed to help develop innovative concepts by integrating multiple contents to produce new, valuable information in the field of education and research, particularly concerning the Problem-Based Learning model in Natural Science education at the elementary school level.

3. Result and Discussion

Based on the results of data abstraction and literature review analysis, supported by the Publish or Perish software, a total of 301 articles related to this research were identified. After excluding 208 irrelevant articles, duplicates, or those that did not meet the criteria for title, abstract, and keywords, 93 articles remained eligible. Upon deeper analysis, only 12 articles met the criteria. The findings of this study are presented in five sections, namely the annual publication trends of the Problem-Based Learning model in science education at the elementary school level, frequently discussed topics, the 10 most-cited papers, the application of the Problem-Based Learning model in science education at elementary schools, and the impact of the Problem-Based Learning model on science education in elementary schools.

Annual Publication Trends of the Problem-Based Learning Model in Science Education at Elementary Schools (2014–2023)

Figure 2 below illustrates the evolution of the Problem-Based Learning model in science education at the elementary school level from 2014 to 2023. Upon examining the annual number of studies on the Problem-Based Learning model in this field, the analysis revealed variations in the number of articles published. The peak year for publications was 2018, with a total of 16 articles published. In 2014 and 2015, the number of articles published was the same, totalling 2 articles each in scientific journals. Subsequently, there was significant growth in 2018, reaching a total of 16 articles. However, in 2019, there was a 19% decline, and a similar trend occurred in 2020 with a 23% decrease. This was followed by an increase in 2021.

From 2021 onwards, the number of journal publications on the Problem-Based Learning model in science education at the elementary level has consistently declined. When analysed annually up to 2023, a total of 93 papers have been published in this field. Researchers project that this topic will continue to attract attention in the field of education. Considering the urgency to enhance and integrate science education at the elementary level through this model, further publications in this area are likely to emerge in the future.

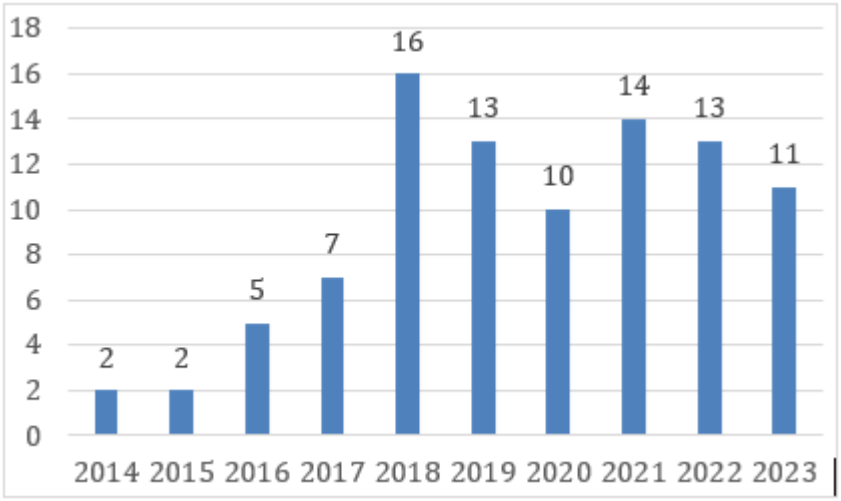

Figure 2. Development of the Problem Based Learning model in science learning in elementary school based on year of publication

Topics Frequently Discussed in the Problem-Based Learning Model for Science Education at Elementary Schools (2014–2023)

Research topics with keywords highlighted in blue represent the most frequently studied areas, while those in orange indicate less frequently explored topics. The most commonly researched topics are related to the Problem-Based Learning (PBL) model, with the most frequently associated subject being science education. The learning outcomes often measured are academic achievement, and the most frequent research subjects are elementary school students.

An article titled “The Application of the Problem-Based Learning Model to Improve Science Learning Outcomes in Grade IV Elementary School Students” by Rahmasari (2016) discusses improving the academic performance of fourth-grade students at SD Negeri Nglempong Ngaglik Sleman. The findings show that the use

of the Problem-Based Learning (PBL) model can significantly improve students' learning outcomes. In the pre-cycle stage, 58.33% of fourth-grade students at SD Negeri Nglempong Ngaglik Sleman met the minimum competency standards (KKM) with scores equal to or greater than 65, while 41.67% did not meet the KKM. The pre-cycle data revealed that students' science learning outcomes were relatively low. After implementing the PBL model in science lessons, the average score increased to 78.58. A total of 95.83% of students met the KKM, while only 4.17% did not. Therefore, it can be concluded that the application of the Problem-Based Learning (PBL) model successfully improved the science learning outcomes of fourth-grade students at SD Negeri Nglempong, Sleman, Yogyakarta, during the 2016/2017 academic year.

Meanwhile, another article titled “Enhancing Critical Thinking Skills and Thematic Science Learning Outcomes through the Problem-Based Learning Model for Grade 5 Students” by Walfajri & Harjono (2019) discusses the implementation of the PBL model for fifth-grade students at SDN Mangunsari 02 Salatiga. Based on the results and discussion, the application of the Problem-Based Learning model effectively enhanced students' critical thinking skills and learning outcomes in science subjects for fifth-grade students at SDN Mangunsari 02 Salatiga. The study revealed that the PBL model significantly improved students' critical thinking skills and academic performance. The analysis of students' critical thinking abilities during the pre-cycle, cycle I, and cycle II showed a significant improvement. This improvement also had a positive impact on students' learning outcomes, as evidenced by comparisons across the pre-cycle, cycle I, and cycle II.

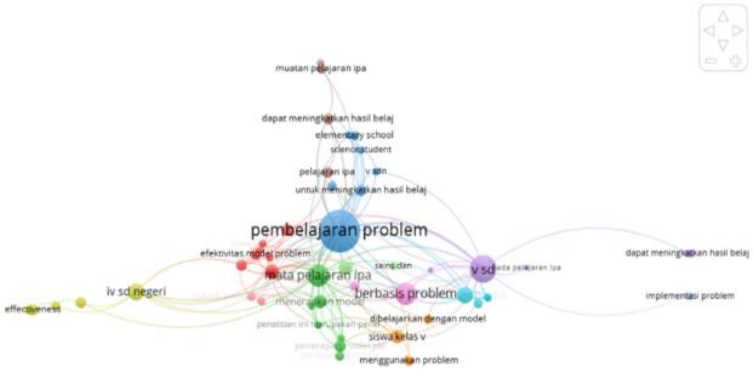

Figure 3. The most frequently researched topics in the Problem-Based Learning model for science education at the elementary school level.

Most Cited Articles on the Problem-Based Learning Model in Science Education at Elementary Schools (2014–2023)

In Table 2 below, there are 10 articles sorted based on the highest number of citations. These articles represent the most cited works on the Problem-Based Learning model in science education at elementary schools.

Tabel 2. The most cited articles on the Problem-Based Learning model in science education at the elementary school level published between 2014 and 2023.

No	Cite	Author	Year	Title
1.	192	F Nuraini	2017	Using the Problem Based Learning (PBL) model for improve science learning outcomes for 5th grade elementary school students
2.	111	AAA Putri	2018	The influence of media-assisted PBL learning models picture of the science learning outcomes of third grade elementary school students
3.	99	PS Devi, GW Bayu	2020	Critical Thinking and Science Learning Outcomes Through Learning Problem Based Learning Assisted by Visual Media
4.	95	FA Astari, S Suroso, Y Yustinus	2018	Effectiveness of using discovery learning models and problem based learning model on science learning outcomes 3rd grade elementary school students
5.	90	TF Kristiana, EH Radia	2021	Meta Analysis of the Application of the Problem Based Learning Model in Improving School Students' Science Learning Outcomes Base
6.	74	R Rahmasari	2020	Application of the Problem Based Learning Model to Improve Science Learning Outcomes for Class IV Elementary School
7.	67	M Safrida,	2018	Application of the problem based learning model

		A Kistian		(PBL) to improve science learning outcomes for Class V Elementary School Peureumeue Country, Kaway District
8.	60	N Harjono	2019	Improved critical thinking skills and learning outcomes thematic science content through a problem based learning model 5th grade elementary school
9.	53	D Kusnandar	2019	The influence of problem based learning models on results cognitive learning and motivation to learn science
10.	53	R Riswati, M Alpusari	2018	Application of the Problem Based Learning Model to Improve Science Learning Outcomes for Class V Elementary School Students Negeri 019 Sekeladi Tanah Putih

Results of Analysis on Cited Articles

The analysis of the table clearly shows that the use of the Problem-Based Learning (PBL) model to enhance science learning outcomes for 5th-grade elementary school students has dominated research attention, garnering the highest number of citations, with 192 citations, authored by Nuraini in 2017. This article emphasizes that PBL is recognized as an effective learning model for improving student outcomes in science education at the elementary level. These findings highlight the significance of PBL as a model that successfully enhances student learning outcomes.

Next, in second place, is an article by AAA Putri published in 2018, receiving 111 citations. Titled The Effect of PBL Model Assisted by Picture Media on Science Learning Outcomes of 3rd Grade Elementary Students, this article demonstrates that students engaged in Problem-Based Learning (PBL) achieved higher learning outcomes. PBL fosters problem-solving abilities, reduces the burden of rote memorization, and provides real-life learning experiences. The use of two-dimensional images in the stages of PBL also increases student motivation. Teachers act as facilitators in an active and structured learning process. The focus of PBL is on understanding the material and developing problem-solving skills.

In third place, with 99 citations, is an article titled Critical Thinking and Science Learning Outcomes through Problem-Based Learning Supported by Visual

Media. This article indicates that students taught using the Problem-Based Learning (PBL) model exhibited superior critical thinking skills compared to students taught using other models. These students displayed high enthusiasm for learning, strong curiosity, and initiative in finding solutions to problems presented by teachers. Their critical thinking skills improved significantly and were classified as higher-order thinking. The application of the PBL model with the support of visual media had a positive impact on elementary school students' science learning outcomes, enhancing their critical thinking abilities. The combination of PBL and visual media created a meaningful and enjoyable learning environment, increased student participation, and motivated them to solve real-life problems.

Implementation of the Problem-Based Learning Model in Improving Science Learning Outcomes in Elementary Schools

The teacher's role in implementing the Problem-Based Learning (PBL) model to overcome challenges in science learning includes several actions, such as inspiring students to actively engage in solving problems, encouraging collaboration among students in learning groups, and guiding students to conduct more hands-on practices after understanding the theories taught by the teacher. In the science learning process, teachers often use media or tools that students can later use in practical activities. Therefore, teachers need to demonstrate creativity in designing learning strategies to enhance students' learning experiences optimally (Ka'u, 2022).

Natural Sciences (IPA) and Their Connection to Problem-Based Learning

Natural Sciences (IPA) are closely related to the problem-based learning model, as IPA involves understanding concepts linked to real-world contexts. The problem-based learning approach places greater emphasis on solving problems or addressing everyday issues as its primary foundation (Hidayah & Pujiastuti, 2016). The application of the Problem-Based Learning (PBL) model in improving science learning outcomes in elementary schools requires the involvement of individuals closely connected to the students, specifically teachers. Based on

findings from the selected articles, the following roles are identified for teachers in implementing the Problem-Based Learning model to enhance learning outcomes, particularly in science education at elementary schools.

Challenges Faced by Teachers in Implementing Problem-Based Learning for Science

The challenges teachers face in implementing science learning to achieve optimal outcomes can be observed from two aspects. First, from the cognitive aspect, students' achievements in science subjects still show a low level of performance. Second, from the affective aspect, students display passive attitudes toward science subjects during the learning process. A lack of student participation in various learning activities, such as answering questions, providing responses, or asking questions, serves as an indicator of this issue (Indriani, 2015).

Impacts of the Problem-Based Learning Model in Science Education at Elementary Schools

Based on findings from the selected articles, the Problem-Based Learning (PBL) model has several impacts on science education at elementary schools. Research conducted aims to identify the impacts of the PBL model in science learning in this context.

Critical thinking skills hold significant importance in the learning context, particularly in Natural Sciences. These skills are a crucial aspect of scientific attitudes that students should possess during the learning process in science. A lack of critical thinking skills can make it difficult for students to solve problems or complete tasks encountered during science lessons (Mareti et al., 2021). The PBL model is believed to improve students' critical thinking skills to the level of HOTS (High-Order Thinking Skills). Students are instructed to carry out several activities, including problem orientation/investigation, organizing for learning/questioning, conducting investigations/data collection, developing and presenting work/results connections, and analysing and evaluating the problem-solving process/communicating, all of which are conducted over two cycles. After these two cycles, it has been proven that the PBL model can enhance critical

thinking skills in science learning at elementary schools (Khasanah & Sunarno, 2023).

Another notable finding is that the PBL model is effective in enhancing creative skills. In the articles analysed, critical and creative skills were found to be dominant, with average effect sizes of 1.73 and 1.89, categorized as very high (Asiah et al., 2023). However, it was also found that the PBL model does not significantly affect or impact students' collaboration skills (Sari & Hafandi, 2022).

Effect size itself is a metric that evaluates the significance of research results by measuring the degree of correlation or difference and the impact of one variable on another. This measure provides additional information to complement the results of statistical significance analysis, and effect size data can be used to compare the influence of a variable across studies that use different measurement scales (Santoso, n.d.).

Learning outcomes are the final consequence of implementing learning activities in the school environment (Astari et al., 2018). Learning outcomes are one of the things that can be improved through the application or use of the Problem Based Learning model. Learning outcomes cover 3 domains, namely cognitive, affective and psychomotor (Nuraini & Kristin, 2017). In line with this, based on selected articles, it is proven that learning outcomes increase with the use of the Problem Based Learning model. The learning outcomes of groups of students who use the Problem Based Learning model are higher compared to groups of students who use other learning models (Ade et al., 2018).

Students' ability to think critically can contribute to achieving learning outcomes, which means that if students have high critical thinking abilities, it is likely that their learning outcomes will also increase (Walfajri & Harjono, 2019). Students' cognitive domains have improved, however, in the affective and psychomotor domains, students have also experienced improvements to become even better because learning experiences do not only focus on the cognitive domain (Pramudya et al., 2019).

4. Conclusion

Based on the review of 12 articles on the Problem-Based Learning model in science education at the elementary school level, published between 2014 and 2023, the analysis revealed fluctuations in research trends over the years. The highest number of studies was conducted in 2018. Additionally, the most-cited article was published in 2017, originating from Indonesia, with 192 citations. The Problem-Based Learning model has been proven effective in enhancing critical thinking, creativity, and students' learning outcomes but does not significantly impact students' collaboration skills.

Reference

Ade, A., Putri, A., Swatra, I. W., Made Tegeh, I. (2018). The Effect of Problem-Based Learning (PBL) Model Assisted by Image Media on the Science Learning Outcomes of Third-Grade Elementary Students. Journal for Lesson and Learning Studies, 1(1).

Amalia, G., & Hardini, A. T. (2020). The Effectiveness of Online-Based Problem-Based Learning Model on the Science Learning Outcomes of Fifth-Grade Elementary Students. Wahana Pendidikan Scientific Journal, 6(3). https://doi.org/10.5281/zenodo.3977422

Asiah, S., Habibah, R., Asrizal, & Fauzi, A. (2023). A Meta-Analysis of the Effect of Problem-Based Learning Model on 21st Century Skills of Students. Nautical: Multidisciplinary Scientific Journal, 2(9).

Astari, F. A., Suroso, S., & Yustinus, Y. (2018). The Effectiveness of Using Discovery Learning Model and Problem-Based Learning Model on the Science Learning Outcomes of Third-Grade Elementary Students. Jurnal Basicedu, 2(1), 1–10.

Cherly Ana Safira, Agung Setyawan, & Tyasmiarni Citrawati. (2020). Identifying the Issues of Science Learning in Third-Grade Students of SDN Buluh 3 Socah. Journal of Science Education, 10(1), 23–29. https://doi.org/10.37630/jpm.v10i1.277

Febiani Musyadad, V., Supriatna, A., & Mulyati Parsa, S. (2019). The Application of Problem-Based Learning Model to Improve Learning Outcomes of Students on Physical Environmental Changes and Their Impact on Land. Jurnal Tahsinia, 1(1), 1–13. https://doi.org/10.57171/jt.v1i1.13

Gulo, A. (2022). The Application of Problem-Based Learning Model in Improving Science Learning Motivation and Outcomes. Educativo: Journal of Education, 1(1), 334–341. https://doi.org/10.56248/educativo.v1i1.58

Hakim, L. (2020). Bibliometric Analysis of Business Incubator Research in Scopus-Indexed Scientific Publications. Procuratio: Journal of Management Science, 8(2), 176–189. http://www.ejournal.pelitaindonesia.ac.id/ojs32/index.php/PROCURATIO/article/view/677

Hidayah, R., & Pujiastuti, P. (2016). The Impact of PBL on Science Process Skills and

Cognitive Learning Outcomes in Science for Elementary School Students. Jurnal Prima Edukasia, 4(2), 186. https://doi.org/10.21831/jpe.v4i2.7789

Indrawati, F. A., & Wardono, W. (2019). The Impact of Self-Efficacy on Mathematical Literacy Skills and the Development of 4C Competencies. PRISMA, Seminar Proceedings… https://journal.unnes.ac.id/sju/index.php/prisma/article/view/29307

Indriani, F. (2015). Teacher Pedagogical Competence in Managing Science Learning in Elementary and Islamic Elementary Schools. Fenomena, 7(1), 17. https://doi.org/10.21093/fj.v7i1.267

Ka'u, H. (2022). The Implementation of Problem-Based Learning Model to Improve Science Learning Outcomes in Fifth-Grade Students of SDN Watutura for the 2019/2020 Academic Year. 6(1), 3329–3335.

Khasanah, S. U., & Sunarno. (2023). Improving Learning Outcomes on the Topic of Force Using Problem-Based Learning Model for Fourth-Grade Students of SDN Kelayan Dalam 7. JUPENJI: Jurnal Pendidikan Jompa Indonesia, 2.

Linnenluecke, M. K., Marrone, M., & Singh, A. K. (2020). Conducting Systematic Literature Reviews and Bibliometric Analyses. Australian Journal of Management, 45(2), 175–194. https://doi.org/10.1177/0312896219877678

Mareti, J. W., Herlina, A., & Hadiyanti, D. (2021). Problem-Based Learning Model to Enhance Critical Thinking Skills and Science Learning Outcomes of Students. Jurnal Elementaria Edukasia, 4(1), 31–41. https://doi.org/10.31949/jee.v6i1

Nuraini, F., & Kristin, F. (2017). The Use of Problem-Based Learning (PBL) Model to Improve Science Learning Outcomes of Fifth-Grade Students. e-jurnalmitrapendidikan, 1(4), 369–379.

Nurdewi, N. (2022). Adaptation of ASNs' Management in North Maluku Towards World-Class Bureaucracy. SENTRI: Journal of Scientific Research, 1(2), 349–356. https://doi.org/10.55681/sentri.v1i2.239

Perry, A., & Hammond, N. (2002). Systematic Reviews: The Experiences of a PhD Student. Psychology Learning & Teaching, 2(1), 32–35. https://doi.org/10.2304/plat.2002.2.1.32

Pramudya, E., Kristin, F., & Anugraheni, I. (2019). Increasing Student Activity and Science Learning Outcomes in Thematic Learning Using PBL. Naturalistic: Journal of Research on Education and Learning, 3(2), 320–329.

Puspitasari, N., Keguruan, F., Ilmu, D., Kristen, U., & Wacana, S. (2016). Implementation of Problem-Based Learning Model. 299–309.
Putri, R. H., & Wardani, N. S. (2021). Improving Thematic Learning Outcomes Through Problem-Based Learning in Online Learning for Fourth-Grade Students. Jurnal Mimbar Ilmu, 26(1), 2021.

Rahmasari, R. (2016). The Application of Problem-Based Learning Model to Improve Science Learning Outcomes in Fourth-Grade Students. In Jurnal Pendidikan Guru Sekolah Dasar Edition (Vol. 36).

Rifai, A., Islam, S. D., & Firdaus, A. (2020). Problem-Based Learning in Science Education. National Workshop on Strengthening Competence of Primary School Teachers SHEs:

Conference Series, 3(3), 2139–2144. https://jurnal.uns.ac.id/shes

Santosa, A. W., Amelia, M. A., & Sarwi, M. (2022). Increasing Student Activity and Science Learning Outcomes Using Problem-Based Learning Model in Fifth-Grade Students of SD Negeri Sudimoro 2 for the 2021/2022 Academic Year. TEACHING: Journal of Innovation in Teaching and Education, 2(2), 234–239. https://doi.org/10.51878/teaching.v2i2.1345

Santoso, A. (n.d.). Descriptive Study of Effect Size in Researches at the Faculty of Psychology, Sanata Dharma University.

Sari, E., & Hafandi, L. (2022). Bioedutech Journal: The Impact of Problem-Based Learning on Students' Collaboration Skills (Vol. 1). http://jurnal.anfa.co.id Triapamungkas, Y. (2022). Development of Android-Based Learning Media for Science Education on Natural Resources, Environment, Technology, and Society for Fourth-Grade Students. STKIP PGRI Pacitan.

Wahono, R. S. (2015). A Systematic Literature Review of Software Defect Prediction: Research Trends, Datasets, Methods, and Frameworks. Journal of Software Engineering, 1(1), 1–16.

Walfajri, R. U., & Harjono, N. (2019). Enhancing Critical Thinking Skills and Thematic Learning Outcomes in Science through Problem-Based Learning Model for Fifth-Grade Students. Jurnal Basicedu, 3(1), 16–20.

Wulandari, E., Budi, H. S., & Suryandari, K. C. (2017). Implementation of Problem-Based Learning Model in Science Education for Fifth-Grade Students. Kalam Cendekia PGSD Kebumen, 1(1), 6. http://www.jurnal.fkip.uns.ac.id

Yuliana, L., Aeni, A. N., & Sujana, A. (2016). The Implementation of Problem-Based Learning Model in Alternative Energy Materials to Improve Learning Outcomes in Students of Class IV-B SDN Conggeang I, Conggeang District, Sumedang Regency. Jurnal Pena Ilmiah, 1(1), 861–870. https://ejournal.upi.edu/index.php/penailmiah/article/view/3579.