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Science problem solving in elementary schools through the application of project-based learning

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Abstract: This study focuses on the lack of widespread training in problem-solving skills among students. This research aims to determine the application of project-based learning (PjBL) to improve students' science problem-solving skills in elementary schools. The study used a quantitative method. The subjects of the study were 21 students of grade III elementary school. The data analysis results show that overall learning was successful, with students achieving an average learning achievement of 80.55% in the very good category. Teachers achieved an average learning achievement of 86.46% in the very good category. The student's learning response was categorized as very good, achieving a percentage of 92.38%. The implementation of learning resulted in a significant increase of 33.86% in student scores. Accordingly, it can be concluded that the problem-solving skills of elementary school students increase after the application of PjBL. In general, the implementation of learning is carried out well, with good categories of teacher and student learning achievements. Students' responses to the learning implementation met very good criteria.

Keywords: Problem solving, project based learning, science

Abstrak: Penelitian ini berfokus pada kurangnya pelatihan keterampilan pemecahan masalah secara luas di kalangan siswa. Penelitian ini bertujuan untuk mengetahui penerapan Project Based Learning (PjBL) untuk meningkatkan keterampilan pemecahan masalah sains siswa di sekolah dasar. Penelitian ini menggunakan metode kuantitatif. Subjek penelitian adalah siswa kelas III Sekolah Dasar yang berjumlah 21 orang. Hasil analisis data menunjukkan bahwa pembelajaran secara keseluruhan berhasil, dengan rata-rata prestasi belajar siswa mencapai 80,55% dengan kategori sangat baik. Guru memperoleh rata-rata prestasi belajar sebesar 86,46% dengan kategori sangat baik. Respon belajar siswa berkategori sangat baik dengan persentase sebesar 92,38%. Keterlaksanaan pembelajaran menghasilkan peningkatan nilai siswa yang signifikan sebesar 33,86%. Dengan demikian dapat disimpulkan bahwa kemampuan pemecahan masalah siswa sekolah dasar meningkat setelah penerapan PjBL. Secara umum pelaksanaan pembelajaran terlaksana dengan baik, dengan kategori baik pada prestasi belajar guru dan siswa. Respon siswa terhadap pelaksanaan pembelajaran mendapat kriteria sangat baik.

Kata kunci: Pemecahan masalah, pembelajaran berbasis proyek, sains

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INTRODUCTION

Elementary school is level of formal education where students get their first lessons in the subject of science. Science are first taught at elementary school level, which are included in thematic lessons (Arini & Darmayanti, 2022). The cognitive abilities of elementary age children are still limited to things that are concrete and real (Bujuri, 2018; rosdiana et al., 2023). Therefore, science learning adapts to the level of students' cognitive development. Natural science, also known as science, plays an important part in our daily lives. Learning about science begins in elementary school. Science includes the study of living organisms, the universe, and the dynamic processes that shape them. Mulyasa 2007 stated that the scope of science is everything in the universe which includes: 1) living

things such as humans, animals, and plants and that include their life processes; 2) objects/materials which include liquid objects, solid objects and gas objects; 3) energy and its changes which include sound, heat, magnetism, electricity, light and simple objects; 4) the earth and the universe which include the earth, the solar system as well as all celestial bodies.

Science encompasses three main components: scientific product, scientific processes, and scientific attitudes (Carin & Sund, 1989). The field of Science explores fundamental questions regarding the origins, present conditions, and future of the universe. These questions can be resolved by engaging in scientific endeavors and employing the scientific method (Nunaki et al., 2020). Scientific activities encompass observation and experimentation, culminating in the formulation of conclusions. Darling-Hammond et al. (2020) highlights that science includes more than merely the compilation of facts. It involves various elements such as observation, classification, prediction, experimentation, and drawing conclusions based on test results. The science learning experience of elementary school students affects their future educational development (Nasir et al., 2023. The primary objective of teaching science in elementary schools is to facilitate the acquisition of scientific knowledge and comprehension that can be practically used in daily life (Aydede Yalçin, 2016). Sulistyorini and Suparton (2007) explains that the objectives of science learning include: 1) understanding the natural surroundings; 2) understanding the skills to gain knowledge in the form of process/scientific methods skills; 3) have a scientific attitude towards the natural environment and solve the problems they face.

Additionally, it is designed to foster a favorable disposition towards science, stimulate curiosity, improve skills in problem-solving, and promote an awareness of the connection between science, environment, technology, and society. Teachers must have the ability to develop science concepts that can be effectively applied to dealing with the environment, technology, and society. They should be able to teach problem-solving skills to students, as this is one of the essential thinking skills that students need to develop. Apart from scientific literacy, there are other crucial component of 21st-century skills, such as students' problem-solving abilities. Students need to have this skill because everyone is always coping with different issues (Afnan et al., 2023). Science education often prioritizes the memorization of facts and concepts. The cognitive abilities currently assessed primarily focus on memory and memorization, rather than encompassing higher-order thinking skills such as problem-solving.

Problem-solving skills are essential for students in the 21st century as they contribute to the development of crucial life skills. Wagner et al. 2010 identifies seven essential skills for life in the 21st century: curiosity and imagination, analytical and information access abilities, effective written and oral communication, entrepreneurial spirit and initiative, adaptability and dexterity, leadership and collaboration, and critical thinking and problem-solving skills. The use of these seven life skills, along with the integration of information and communication technology (ICT), can produce significant advantages for students. Problem solving skills refer to an individual's fundamental ability to address and resolve problems through the use of critical, logical, and systematic thinking. Improving problem-solving skills is crucial as it plays a vital role in developing an individual's ability to address and resolve problems in various aspects of life effectively.

According to Polya (1973) problem solving is a logical process used to find solutions to problems. The problem-solving process consists of the following steps: (1) The problem is identified and defined, (2) followed by the development of problem-solving strategies. (3) These strategies are then implemented, and (4) finally, an evaluation is conducted (Suryanti, 2011).

Irianti (2020) outlined four steps in problem solving: understanding the problem, determining the problem-solving strategy plan, finalizing problem-solving strategies, and re-examining the obtained answers. Therefore, teachers must have the ability to teach students in problem-solving skills. Ariawan and Nufus (2017) emphasize the significance of problem-solving skills in students. These skills enable students to assess the sufficiency of data for problem-solving, choose and use appropriate problem-solving strategies, interpret outcomes in relation to the original problem, and verify the accuracy of results or answers. Kurnianto and Sarwono (2023), and Purwati et al. (2019) further emphasize the importance of assisting students in enhancing their science problem-solving skills.

According to the 2018 PISA survey, Indonesia ranked 74th out of all participating countries, placing it sixth from the bottom. Indonesia achieved a score of 396 in the Science category. The obtained result falls significantly below the average score of 489, as reported by the Organisation for Economic Co-operation and Development (OECD). Indonesia ranks ninth from the bottom based on the score. The item test integrates the problem-solving process with collaborative problem-solving competencies. The inadequate science literacy and problem-solving skills among Indonesian students may negatively affect the quality of human resources and impede the advancement of science and technology in Indonesia if not promptly addressed. To address this challenge, it is important to design an engaging learning model that motivates students to develop their concepts. This can be achieved through an interesting and scientifically-oriented approach that incorporates real-life contexts and utilizes the local environment and resources (Purwati, et. al., 2019; Vasminingtya et al., 2014). By doing so, students' active participation can be enhanced, leading to the development of their problem solving skilss (Khatimah et al., 2018). However, the focus on science literacy and problem-solving skills has been limited, with few teachers actively developing and cultivating these skills in the learning process.

Cahyani and Setyawati (2016) identified problem solving as a significant objective within the curriculum's learning process. The primary objective of education is to equip individuals with problem-solving skills to address challenges in their daily lives effectively (Memnun et al., 2012). Problem-solving skills encompass various abilities, such as formulating problem characteristics, organizing problem-solving stages, selecting problem-solving strategies, evaluating accurate information, using appropriate sources, and monitoring the problem-solving process (Aslan, 2021).

Project-Based Learning (PjBL) is an educational approach that incorporates projects into the learning process (Jagantara et al., 2014; Thenu et al., 2023). Buck Institute fo Education (2019) defines PjBL as a pedagogical approach where students actively participate in problem-solving tasks, fostering their autonomy in constructing knowledge and generating authentic student work. Based on the research results of Dole et al. (2017) showed that projects given to students can support students' autonomous attitudes, providing opportunities for students to learn independently. This learning model can

serve as an alternative approach due to its implementation advantages, such as promoting active and contextual learning. Ngalimun (2013) suggests that this approach engages students in problem-solving activities that follow the scientific method, enabling them to acquire knowledge relevant to the problem while developing problem-solving skills.

The advantages of PjBL according to Rusman (2017) include: 1) increasing student learning motivation; 2) improving problem solving abilities; 3) making students more active and successful in solving complex problems; 4) increasing collaboration; 5) encouraging students to develop communication skills; 6) improving students' abilities in managing learning resources; 7) providing students with experience and practice in organizing projects, managing time allocation and completing assignments; 8) providing learning experiences that involve students in a complex and contextual manner; 9) involving students in learning to find information, demonstrating the knowledge they have, and implementing it in the real world; and 10) making the learning atmosphere enjoyable. The research results of Rasyid et al. (2023) show that PjBL is effective for improving problem-solving skills. PjBL also has a positive influence on elementary school students' science learning outcomes (Mayuni et al., 2019).

Teachers have the autonomy to select and design instructional content that focuses on the development of problem-solving abilities. Teachers have the freedom to engage in critical and creative thinking by making connections between science concepts and real-world problems in their environment. This is essential for promoting problem-solving skills. Based on the provided background information, this study aims to investigate whether the implementation of PjBL can enhance science problem-solving skills in elementary schools. This study aimed to investigate the implementation of Project Based Learning in elementary schools to improve science problem-solving skills, student responses to learning, as well as the challenge experienced during implementation

METHOD

This study used a quantitative method. The purpose of this study is to examine the application of Project Based Learning (PjBL) on scientific students' problem-solving abilities, their responses to the learning, and the challenges that the students encountered when implementing PjBL in elementary schools. This study addresses the issue of training problem-solving skills, specifically focusing on the clean water crisis affecting various regions in Indonesia, including in the environment around students. The study included 21 grade III elementary school students as participants. The study was conducted at SDN Sawocangkring Sidoarjo.

The research instruments used are: teacher and student activity observation sheets, pretest and posttest items, student response questionnaire, and lesson plans. The research procedures conducted are outlined below. (1) The first stage is the preparatory stage. At this stage, researchers conduct preliminary studies to determine research samples, literature studies, instruments such as student response questionnaire sheets, teacher and student activity observation sheets, as well as pretest and posttest questions. These instruments are then tested, and lesson plan and learning media are developed for use in the future. (2) The implementation phase is conducted based on the learning activities outlined in lesson plan, following the syntax of the PjBL model. Learning was carried out in accordance with the PjBL syntax listed in Table 1.

Table 1. Learning steps of PjBL

Stages	Information
Pre-Project	At this stage the teacher designs a project that will be used to train students' problem-solving skills, prepare learning resources and learning media.
Phase-1: Analyze the problem.	At this stage, students watched videos containing news about water crises that hit various regions in Indonesia. Based on the results of observations that have been carried out, then students identify problems and make problem formulations in the form of questions.
Phase-2: Create a Project Design and Implementation Schedule.	At this stage students in groups and with the assistance of teachers begin to design the project they will make, and make preparations for the work.
Phase-3: Carry out research.	At this stage students carry out research activities according to their project, and further analyze the results.
Phase-4: Drafting / prototype products.	At this stage students create the product of the project they have designed.
Phase-5: Measuring, assessing, and improving the product.	At this stage students examine and reanalyze the products that have been produced, as well as carry out class discussion activities to assess the results of the project, listen to suggestions and criticisms from friends and teachers regarding the products that have been produced.
Phase-6: Product finalization and publication.	At this stage, students carry out the finalization of the product of the project results they have worked on as a form of problem solving. After it is felt to be in accordance with expectations, the product is then published by presentation in front of the class.
Post Project.	At this stage the teacher assesses, provides reinforcement, input, and suggestions for improvements to the product as a form of problem solving that students have produced.

During the research phase, the researchers divided the steps into two parts. Firstly, the students were given a preliminary test, also known as a pretest, to assess their problem-solving abilities. The learning process follows the PjBL model, consisting of three meetings during which researchers complete observation sheets. Once the learning process concludes, an evaluation is conducted by administering written tests (posttests) to assess students' problem-solving abilities. These test results are then analyzed to determine the outcomes of student learning. (3) The evaluation phase. During this phase, data collection, processing, and analysis activities are conducted. Next, analyze the pretest and posttest outcomes of each student for comparison. Moreover, the acquired data will undergo quantitative analysis and be described descriptively.

The quantitative analysis was conducted on the data obtained from the student response questionnaire. The study employed problem solving indicators, including understanding the problem, planning, problem solving, and re-checking. This study quantitatively analyzes the implementation of the PjBL model for developing problem-

solving skills. Categories for student problem solving were adopted from research by Damopolii et al. (2018).

RESULTS AND DISCUSSION

The implementation of PjBL in elementary schools to enhance science problem-solving skills involves three research stages: preparation, implementation, and evaluation. The application of the PjBL model in education aims to develop students' problem-solving skills in addressing the clean water crisis in various regions of Indonesia. The research was conducted as planned, consisting of three meetings.

The preparation stage involves conducting a literature review, creating research instruments such as observation sheets for teachers and students, questionnaires for student responses, pretests, and posttests. It also includes developing lesson plans, teaching materials, learning resources, and learning media. The purpose of this validation process is to ensure the validity of research instruments, learning tools, and learning media that have been developed for the collection of research data. The validation results indicate that the research instruments, learning devices, and learning media are valid and suitable for collecting research data. The research implementation stage involves the application of the PjBL learning model. The learning steps used in the application are tailored to the syntax of the PjBL model.

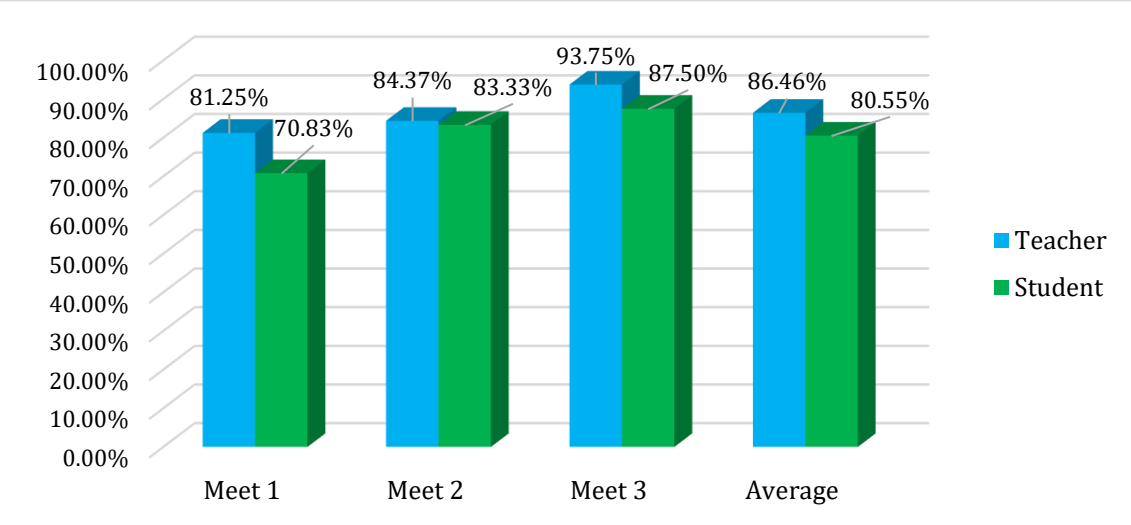

Fig. 1. Observation data toward teacher and student activities

The analysis of teacher and student activities in Figure 1 shows that the implementation of PjBL effectively improves problem-solving skills. The average learning achievement of teachers was 86.46% in the very good category, while students achieved an average learning achievement of 80.55% in the very good category. Table 2 displays the pretest and posttest scores of the students.

Table 2. Pretest and posttest score analysis results data

Average Score		Enhancement
Pretest	**Posttest**	
39.28	73.14	33.86

Based on Table 2, it can be seen that there is an increase in student scores with a percentage of 33.86. The data acquisition process is obtained with the help of initial test (Pretest) and final test sheet (Posttest) instruments, which contain a number of 7 problem solving questions. Table 3 presents the findings from the analysis of the student response questionnaire sheet.

Table 3. Student response data

No	Questions	Strongly Agree	Agree	Neutral	Dissagree
1	I really enjoy taking part in science learning using project-based learning.	17 (80.96%)	2 (9.52%)	2 (9.52%)	0 (0%)
2	I really enjoy practicing science problem solving with project-based learning.	18 (85.71%)	2 (9.52%)	1 (4.76%)	0 (0%)
3	I really enjoy working with my friends in completing projects given by the teacher.	20 (95.24%)	1 (4.76%)	0 (0%)	0 (0%)
4	The media used by teachers in learning can help me to solve problems in projects given by the teacher.	18 (85.71%)	2 (9.52%)	1 (4.76%)	0 (0%)
5	Learning using project-based learning makes me even more interested in studying science.	20 (95.24%)	1 (4.76%)	0 (0%)	0 (0%)
6	Through the lessons provided by the teacher, I increasingly realize the importance of protecting the environment.	21 (100%)	0 (0%)	0 (0%)	0 (0%)
7	After participating in project-based learning, I was motivated to find solutions to every problem I faced.	12 (57.14%)	6 (28.57%)	2 (9.52%)	1 (4.76%)
8	Project-based learning makes me better understand the steps I need to take to solve problems.	15 (71.43%)	6 (28.57%)	0 (0%)	0 (0%)
9	Project-based learning made me aware of respecting the ideas and ideas of my friends.	20 (95.24%)	1 (4.76%)	0 (0%)	0 (0%)
10	I felt that I had no difficulty following this project-based learning.	10 (47.62%)	2 (9.52%)	5 (23.81%)	4 (19.05%)
Average of student response		81.43 %	10.95 %	5.24 %	2.38 %

The data analysis shows that 92.38% of students responded positively (strongly agree and agree), meeting the criteria for a very good category. The results show that students have a favorable perception of the implementation of the PjBL model for developing problem-solving abilities. Despite the high level of student engagement and the effective criteria for implementing project-based learning to enhance problem-solving skills, there remains a discrepancy between student response and their academic performance.

The data analysis shows a significant increase in student scores from the pretest to the posttest following implementing a PjBL to improve problem-solving skills. The percentage increase observed is 33.86%. The results show that students' science problem-solving skills are improved through the implementation of a PjBL. The PjBL learning model has the advantage of promoting independence and improving students' problem-solving skills (Eliza et al., 2019).

The results of Billah et al. (2019) study are expected to be a reference for implementing PjBL in empowering HOTs for student. The PjBL synthesis in sequence includes the phases: launch project; building knowledge; develop and criticize; and present the product. Problem-solving skills are essential higher-order thinking skills that should be developed in elementary school students. The rise in student scores from pretest to posttest following the implementation of a PjBL for practicing problem-solving skills can indicate the development of students' rational thinking abilities in problem-solving. The problem-solving indicators utilized in this study include problem understanding, planning, problem solving, and re-evaluation. According to Tepi et al. (2022) intelligence can be defined as the capacity to engage in rational problem-solving by Using available resources and facilities.

The increase in student scores from pretest to posttest is closely linked to the adoption of a project-based learning model known as Project PjBL, which emphasizes problem-solving skills. Based on the observations of teacher and student activities, the implementation of PjBL to develop problem-solving skills is generally successful. The average achievement score for teachers is 86.46%, categorized as very good, while the average achievement score for students is 80.55%, categorized as very good. The results show that the learning process aligns with the syntax and steps of the project-based learning model (PjBL), which incorporates problem-solving skills. Fauzia and Kelana (2020) found that implementing the PjBL model resulted in a 27% increase in learning quality, indicating improved problem-solving abilities. Implementing project-based learning has increased student engagement in science (Beluan et al., 2018; Roosyanti, 2020).

The analysis of student responses to the implementation of project-based learning for practicing problem-solving skills yielded a high success rate of 92.38%, indicating excellent performance. Despite the students' commendable criteria, their responses did not align with the results of the student scores, which experienced a relatively modest increase of 33.86%. These findings have laid the groundwork for enhancing students' problem-solving abilities by fostering their motivation and enthusiasm for learning. Ngalimun (2013) suggests engaging students in the problem solving process using the scientific method to enhance their problem-solving abilities. PjBL is a model in which students engage in problem-solving by working on a useful project (Sani, 2014).

The implementation of the project-based learning model can effectively enhance the problem-solving abilities of students with low literacy levels. These findings align with previous research conducted by Isa et al. (2023), which demonstrated that engaging children in problem-solving activities can enhance their active participation and enthusiasm in the learning process, thereby preventing monotony and boredom. Using diverse learning resources and media, along with contextual projects, can mitigate challenges encountered by elementary school students when solving science problems.

CONCLUSION

The research concluded that the problem-solving skills of elementary school students increased after the application of Project Based Learning. The use of project-based learning improved students' science problem-solving skills. Overall, the learning process was effectively executed, with teachers' and students' learning outcomes satisfactory. Students' feedback on applying project-based learning to enhance problem-solving skills was highly positive and met rigorous evaluation criteria. These findings created foundations to improve students' problem-solving abilities by promoting their motivation and enthusiasm to engage in learning by implementing a project-based learning approach. Using diverse learning resources and media, along with contextual projects, can mitigate challenges for elementary school students when solving science problems.

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